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# THE PHILIPPINE JOURNAL OF SCIENCE

VOL. 53 JANUARY, 1934 No. 1

## LEPROSY IN CEBU, II

By J. RODRIGUEZ and F. C. PLANTILLA
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### GENERAL DATA

#### PRESENT SURVEY

In a report that appeared in 1931 [1] on the incidence of leprosy in Cebu Province written by the senior author, it was stated that a marked focal or spotted distribution of the disease existed in the province. The explanation for this was not apparent, although there was a certain correlation between density of population and prevalence of leprosy. The climate was not considered important, at least in Cebu. A brief history of the disease in this province was also given.

Since the publication of this paper, examination of contacts to recently discovered lepers has been undertaken by the Cebu Skin Dispensary, but due to the lack of personnel and, especially, of funds for transportation, this could not be done systematically.

In December, 1932, it was decided to visit systematically the homes of all newly reported "closed" and "open" cases of leprosy that could be reached on foot within the city of Cebu and its environs. At the same time, it was planned to make a thorough health survey of the barrio of Baud in the district of San Nicolas, which was the best-known focus of the disease in Cebu Island. This barrio is bounded on the north by Carlock Street, on the east by Tuti Street, on the west by C. Padilla

[1] Philip. Journ. Sci. 45 (1931) 459–481.

Street, and on the south by Pagina River. It has an area of less than half a square mile and is estimated to contain about 600 households, representing approximately 3,500 people. This was to serve as the control for the urban cases occurring in the city of Cebu. To aid in this undertaking and in order to establish a liaison with the people of the district, a branch of the dispensary was established there.

At the same time, a similar survey of the normal population was started on the outskirts of the town of Opon, which is situated on Mactan Island just across the narrow Cebu Strait from the capital. This was to provide a control for the rural cases of leprosy. It was intended to visit another 600 homes in this district.

In addition, the former homes of many of the lepers segregated during the last two years as well as the houses of some of the registered "closed" cases and paroled ex-lepers were also surveyed. As too few of the contacts of recent positive cases could be located, it was decided to include some of those segregated as long as three years previously and in a few instances even longer than this. This introduced a very grave source of error in the interpretation of some of the data covered by this preliminary report, but it was felt that the records obtained would prove useful in the future when other secondary cases in these households may be expected to develop. This subject will be discussed more fully later.

To May 15, 1933, it has been possible to secure epidemiological data on ninety-five nonleper households in the barrio of Baud. Unfortunately, the survey had to be started in what was perhaps the poorest part of the barrio, so that these control families appeared to be poorer than the average and did not seem truly representative of the households in the barrio. However, the results so far are not devoid of some interest.

On the other hand, the control rural households surveyed at Opon, of which there were 215, were possibly better off than the average, as they are generally nearer to the town than most of the leprous households visited and consequently had better chances for employment in the few industrial establishments located in Opon. Needless to say, these inequalities will tend to disappear both at Baud and at Opon as more control families are surveyed.

In most of the subsequent analyses of our data, the control and "leper" groups from both places have been combined; al-

though such a step is open to many objections, it tended to make this group more nearly representative of the normal population of Cebu Province.

However, whenever interesting or any marked differences appeared to exist between the urban and rural sets of control and "leper" households, these were also discussed or at least mentioned in the present report. For this reason, tables covering the most important data, such as the population, etc., for the Cebu (urban) and the Mactan (rural) control and "leper" families, are given separately.

## POPULATION

In the city of Cebu, 193 households were surveyed of whom 95 were control families living in the barrio of Baud, 16 were households which have been exposed to a "positive" case of leprosy in the district of San Nicolas, and 16 were households similarly exposed but were located outside of San Nicolas district, although still within the city limits. Twenty-seven other households in San Nicolas had one or more incipient cases of leprosy among their members, while 39 others outside of this

TABLE 1.—*Population, by age and sex, of Cebu households surveyed.*

| Age. | Controls (95 families). | | | Incipients (66 families). | | | Positives (32 families). | | | Total lepers (98 families). | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | | | | | | | |
| 1— | 6 | 5 | 11 | 6 | 8 | 14 | 1 | 1 | 2 | 7 | 9 | 16 |
| 1 | 9 | 5 | 14 | 5 | 1 | 6 | 4 | 0 | 4 | 9 | 1 | 10 |
| 2 | 4 | 3 | 7 | 5 | 6 | 11 | 4 | 3 | 7 | 9 | 9 | 18 |
| 3 | 8 | 7 | 15 | 9 | 2 | 11 | 1 | 0 | 1 | 10 | 2 | 12 |
| 4 | 5 | 2 | 7 | 11 | 4 | 15 | 3 | 0 | 3 | 14 | 4 | 18 |
| 5– 9 | 32 | 24 | 56 | 24 | 33 | 57 | 15 | 12 | 27 | 39 | 45 | 84 |
| 10–14 | 24 | 27 | 51 | 22 | 36 | 58 | 9 | 11 | 20 | 31 | 47 | 78 |
| 15–19 | 29 | 42 | 71 | 28 | 35 | 63 | 17 | 23 | 40 | 45 | 58 | 103 |
| 20–29 | 47 | 70 | 117 | 38 | 46 | 84 | 23 | 22 | 45 | 61 | 68 | 129 |
| 30–39 | 33 | 23 | 56 | 18 | 26 | 44 | 9 | 7 | 16 | 27 | 33 | 60 |
| 40–49 | 20 | 20 | 40 | 17 | 22 | 39 | 10 | 12 | 22 | 27 | 34 | 61 |
| 50–59 | 6 | 18 | 24 | 12 | 10 | 22 | 5 | 5 | 10 | 17 | 15 | 32 |
| 60–69 | 12 | 10 | 22 | 4 | 7 | 11 | 3 | 4 | 7 | 7 | 11 | 18 |
| 70–79 | 2 | 1 | 3 | 1 | 4 | 5 | 0 | 0 | 0 | 1 | 4 | 5 |
| 80–89 | 0 | 2 | 2 | 1 | 2 | 3 | 1 | 0 | 1 | 2 | 2 | 4 |
| 90+ | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| Total | 239 | 259 | 498 | 201 | 242 | 443 | 105 | 101 | 206 | 306 | 343 | 649 |

TABLE 2.—*Population, by age and sex, of Mactan households surveyed.*

| Age. | Controls (215 families). | | | Incipients (25 families). | | | Positives (56 families). | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | | | | |
| Less than 1 | 46 | 30 | 76 | 1 | 3 | 4 | 3 | 3 | 6 |
| 1 | 16 | 13 | 29 | 1 | 0 | 1 | 0 | 4 | 4 |
| 2 | 19 | 18 | 37 | 4 | 1 | 5 | 6 | 7 | 13 |
| 3 | 32 | 33 | 65 | 1 | 3 | 4 | 3 | 4 | 7 |
| 4 | 22 | 18 | 40 | 1 | 1 | 2 | 3 | 5 | 8 |
| 5 to 9 | 117 | 100 | 217 | 13 | 6 | 19 | 29 | 24 | 53 |
| 10 to 14 | 80 | 77 | 157 | 8 | 15 | 23 | 18 | 22 | 40 |
| 15 to 19 | 68 | 71 | 139 | 11 | 11 | 22 | 18 | 22 | 40 |
| 20 to 29 | 130 | 135 | 265 | 8 | 12 | 20 | 29 | 28 | 57 |
| 30 to 39 | 71 | 69 | 140 | 6 | 7 | 13 | 8 | 16 | 24 |
| 40 to 49 | 36 | 35 | 71 | 9 | 5 | 14 | 17 | 11 | 28 |
| 50 to 59 | 21 | 20 | 41 | 3 | 8 | 11 | 7 | 14 | 21 |
| 60 to 69 | 9 | 22 | 31 | 3 | 2 | 5 | 4 | 6 | 10 |
| 70 to 79 | 3 | 3 | 6 | 0 | 3 | 3 | 5 | 4 | 9 |
| 80 to 89 | 2 | 1 | 3 | 1 | 2 | 3 | 1 | 1 | 2 |
| 90+ | 0 | 2 | 2 | 0 | 1 | 1 | 0 | 1 | 1 |
| Total | 672 | 647 | 1,319 | 70 | 80 | 150 | 151 | 172 | 323 |

| Age. | Paroled (34 families). | | | Contacts (115 families). | | |
|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | |
| Less than 1 | 2 | 1 | 3 | 6 | 7 | 13 |
| 1 | 1 | 4 | 5 | 2 | 8 | 10 |
| 2 | 4 | 1 | 5 | 14 | 9 | 23 |
| 3 | 6 | 1 | 7 | 10 | 8 | 18 |
| 4 | 4 | 3 | 7 | 8 | 9 | 17 |
| 5 to 9 | 8 | 15 | 23 | 50 | 45 | 95 |
| 10 to 14 | 22 | 9 | 31 | 48 | 46 | 94 |
| 15 to 19 | 13 | 15 | 28 | 42 | 48 | 90 |
| 20 to 29 | 12 | 19 | 31 | 49 | 59 | 108 |
| 30 to 39 | 4 | 11 | 15 | 18 | 34 | 52 |
| 40 to 49 | 8 | 11 | 19 | 34 | 27 | 61 |
| 50 to 59 | 3 | 5 | 8 | 13 | 27 | 40 |
| 60 to 69 | 2 | 5 | 7 | 9 | 13 | 22 |
| 70 to 79 | 0 | 1 | 1 | 5 | 8 | 13 |
| 80 to 89 | 1 | 0 | 1 | 3 | 3 | 6 |
| 90+ | 0 | 0 | 0 | 0 | 2 | 2 |
| Total | 90 | 101 | 191 | 311 | 353 | 664 |

TABLE 3.—*Population, by age and sex, Cebu and Mactan combined.*

| Age. | Controls (310 families).[a] | | | Incipients (91 families).[b] | | | Positives (88 families).[c] | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | | | | |
| Less than 1 | 52 | 35 | 87 | 7 | 11 | 18 | 4 | 4 | 8 |
| 1 | 25 | 18 | 43 | 6 | 1 | 7 | 4 | 4 | 8 |
| 2 | 23 | 21 | 44 | 9 | 7 | 16 | 10 | 10 | 20 |
| 3 | 40 | 40 | 80 | 10 | 5 | 15 | 4 | 4 | 8 |
| 4 | 27 | 20 | 47 | 12 | 5 | 17 | 6 | 5 | 11 |
| 5 to 9 | 149 | 124 | 273 | 37 | 39 | 76 | 44 | 36 | 80 |
| 10 to 14 | 104 | 104 | 208 | 30 | 51 | 81 | 27 | 33 | 60 |
| 15 to 19 | 97 | 113 | 210 | 39 | 46 | 85 | 35 | 45 | 80 |
| 20 to 29 | 177 | 205 | 382 | 46 | 58 | 104 | 52 | 50 | 102 |
| 30 to 39 | 104 | 92 | 196 | 24 | 33 | 57 | 17 | 23 | 40 |
| 40 to 49 | 56 | 55 | 111 | 26 | 27 | 53 | 27 | 23 | 50 |
| 50 to 59 | 27 | 38 | 65 | 15 | 18 | 33 | 12 | 19 | 31 |
| 60 to 69 | 21 | 32 | 53 | 7 | 9 | 16 | 7 | 10 | 17 |
| 70 to 79 | 5 | 4 | 9 | 1 | 7 | 8 | 5 | 4 | 9 |
| 80 to 89 | 2 | 3 | 5 | 2 | 4 | 6 | 2 | 1 | 3 |
| 90+ | 2 | 2 | 4 | 0 | 1 | 1 | 0 | 2 | 2 |
| Total | 911 | 906 | 1,817 | 271 | 322 | 593 | 256 | 273 | 529 |

| Age. | Paroled (34 families).[d] | | | Total lepers (213 families).[e] | | |
|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | |
| Less than 1 | 2 | 1 | 3 | 13 | 16 | 29 |
| 1 | 1 | 4 | 5 | 11 | 9 | 20 |
| 2 | 4 | 1 | 5 | 23 | 18 | 41 |
| 3 | 6 | 1 | 7 | 20 | 10 | 30 |
| 4 | 4 | 3 | 7 | 22 | 13 | 35 |
| 5 to 9 | 8 | 15 | 23 | 89 | 90 | 179 |
| 10 to 14 | 22 | 9 | 31 | 79 | 93 | 172 |
| 15 to 19 | 13 | 15 | 28 | 87 | 106 | 193 |
| 20 to 29 | 12 | 19 | 31 | 110 | 127 | 237 |
| 30 to 39 | 4 | 11 | 15 | 45 | 67 | 112 |
| 40 to 49 | 8 | 11 | 19 | 61 | 61 | 122 |
| 50 to 59 | 3 | 5 | 8 | 30 | 42 | 72 |
| 60 to 69 | 2 | 5 | 7 | 16 | 24 | 40 |
| 70 to 79 | 0 | 1 | 1 | 6 | 12 | 18 |
| 80 to 89 | 1 | 0 | 1 | 5 | 5 | 10 |
| 90+ | 0 | 0 | 0 | 0 | 3 | 3 |
| Total | 90 | 101 | 191 | 617 | 696 | 1,313 |

[a] Controls = 310 households, 1,817 persons or 5.8 persons per household.

[b] Incipients = 91 households, 593 persons or 6.5 persons per household.

[c] Positives = 88 households, 529 persons or 6.0 persons per household.

[d] Paroled = 34 households, 191 persons or 5.6 persons per household.

[e] Total lepers = 213 households, 1,313 persons or 6.2 persons per household. Total controls and lepers: 523 households, 3,130 persons or 6.0 persons per household.

TABLE 4.—*Population, by age and sex, control and leper inhabitants of Cebu and Mactan combined.*

| Age. | Controls.[a] | | | | | | Leper households.[b] | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Males. | | Females. | | Total. | | Males. | | Females. | | Total. | |
| *Yrs.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 1— | 52 | 5.7 | 35 | 3.9 | 87 | 4.8 | 13 | 2.1 | 16 | 2.3 | 29 | 2.2 |
| 1 | 25 | 2.7 | 18 | 2.9 | 43 | 2.4 | 11 | 1.8 | 9 | 1.3 | 20 | 1.5 |
| 2 | 23 | 2.5 | 21 | 2.3 | 44 | 2.4 | 23 | 3.7 | 18 | 2.6 | 41 | 3.1 |
| 3 | 40 | 4.4 | 40 | 4.4 | 80 | 4.4 | 20 | 3.2 | 10 | 1.4 | 30 | 2.3 |
| 4 | 27 | 3.0 | 20 | 2.2 | 47 | 2.6 | 22 | 3.6 | 13 | 1.9 | 35 | 2.7 |
| 5– 9 | 149 | 16.4 | 124 | 13.7 | 273 | 15.0 | 89 | 14.4 | 90 | 12.9 | 179 | 13.6 |
| 10–14 | 104 | 11.4 | 104 | 11.5 | 208 | 11.4 | 79 | 12.8 | 93 | 13.4 | 172 | 13.1 |
| 15–19 | 97 | 10.6 | 113 | 12.5 | 210 | 11.6 | 87 | 14.1 | 106 | 15.2 | 193 | 14.7 |
| 20–29 | 177 | 19.5 | 205 | 22.6 | 382 | 21.0 | 110 | 17.8 | 127 | 18.3 | 237 | 18.0 |
| 30–39 | 104 | 11.4 | 92 | 10.1 | 196 | 10.8 | 45 | 7.3 | 67 | 9.7 | 112 | 8.5 |
| 40–49 | 56 | 6.1 | 55 | 6.1 | 111 | 6.1 | 61 | 9.9 | 61 | 8.8 | 122 | 9.3 |
| 50–59 | 27 | 3.0 | 38 | 4.2 | 65 | 3.6 | 30 | 4.9 | 42 | 6.0 | 72 | 5.5 |
| 60–69 | 21 | 2.3 | 32 | 3.5 | 53 | 2.9 | 16 | 2.6 | 24 | 3.4 | 40 | 3.0 |
| 70–79 | 5 | 0.5 | 4 | 0.4 | 9 | 0.5 | 6 | 1.0 | 12 | 1.7 | 18 | 1.4 |
| 80–89 | 2 | 0.2 | 3 | 0.3 | 5 | 0.3 | 5 | 0.8 | 5 | 0.7 | 10 | 0.8 |
| 90+ | 2 | 0.2 | 2 | 0.2 | 4 | 0.2 | 0 | 0.0 | 3 | 0.4 | 3 | 0.2 |
| Total | 911 | 99.9 | 906 | 99.9 | 1,817 | 100.0 | 617 | 100.0 | 696 | 100.0 | 1,313 | 99.9 |

[a] Controls: Males = 911, or 51.1 per cent; females = 906, or 49.9 per cent.
[b] Leper households: Males = 617, or 46.9 per cent; females = 696, or 53.0 per cent.

district also had incipient lepers. Summarizing, there were 95 control households and 98 "leper" households; of the latter, 66 were exposed to incipient or "closed" cases and 32 to positive cases.

The population, by age and sex, of the control and "leper" households in the city of Cebu, appears in Table 1. There were 498 individuals of both sexes in the control group and 649 in the "leper" group. These latter represent the "contacts" to the disease.

In the town of Opon, there were visited 215 control households, 25 homes with "closed" cases, 56 with positive cases, and 34 with "paroled" negative lepers, making a total of 330 households surveyed, with 1,983 inhabitants. Table 2 gives the population, by age and sex, of these households.

In Table 3 the urban and rural groups have been combined. The control households total 310 houses, with 1,817 persons or 5.8 persons per household. There were 91 households with closed cases of leprosy, representing 593 contacts among them. In 88 homes, 529 persons were exposed to a "positive" or "open" case, while 191 individuals in 34 homes were in contact with

paroled ex-lepers. Summarizing, there were 310 households with 1,817 persons in the control group and 213 households with 1,313 people in the "leper" group, making a total of 523 households surveyed, representing 3,130 people.

Table 4 gives the percentage of distribution, by age and sex, of the entire population in the two groups. Among the controls, 911, or 51.1 per cent, were males and 906, or 49.9 per cent, were females, while of the total population of 1,313 in households where cases of leprosy have appeared, 617, or 46.9 per cent, were males and 696, or 53 per cent, were females.

TABLE 5.—*Occupation, arranged in broad groups, of control and leper contact population of Mactan and Cebu combined.*

| Occupation. | Controls. | | | | | |
|---|---|---|---|---|---|---|
| | Males. | | Females. | | Total. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 1. Domestic | 6 | 1.0 | 47 | 7.3 | 53 | 4.3 |
| 2. Employee | 26 | 4.4 | 3 | 0.5 | 29 | 2.3 |
| 3. Farmer | 33 | 5.6 | 0 | 0.0 | 33 | 2.6 |
| 4. Fisherman | 64 | 10.8 | 7 | 1.1 | 71 | 5.7 |
| 5. Merchant | 14 | 2.4 | 44 | 6.8 | 58 | 4.7 |
| 6. Ordinary laborer | 207 | 34.9 | 8 | 1.2 | 215 | 17.3 |
| 7. Skilled laborer | 46 | 7.8 | 34 | 5.2 | 80 | 6.5 |
| 8. Professional | 3 | 0.5 | 1 | 0.2 | 4 | 0.3 |
| 9. Property owner | 1 | 0.2 | 0 | 0.0 | 1 | 0.1 |
| 10. Student | 90 | 15.1 | 68 | 10.5 | 158 | 12.7 |
| 11. Housework | 0 | 0.0 | 387 | 59.7 | 387 | 31.2 |
| 12. No occupation | 103 | 17.3 | 49 | 7.6 | 152 | 12.2 |
| Total | 593 | 100.0 | 648 | 100.1 | 1,241 | 99.9 |

| Occupation. | Leper contacts. | | | | | |
|---|---|---|---|---|---|---|
| | Males. | | Females. | | Total. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 1. Domestic | 7 | 1.6 | 37 | 6.8 | 44 | 4.5 |
| 2. Employee | 28 | 6.4 | 4 | 0.7 | 32 | 3.3 |
| 3. Farmer | 38 | 8.7 | 24 | 4.4 | 62 | 6.3 |
| 4. Fisherman | 23 | 5.2 | 0 | 0.0 | 23 | 2.3 |
| 5. Merchant | 13 | 3.0 | 40 | 7.3 | 53 | 5.4 |
| 6. Ordinary laborer | 130 | 29.6 | 12 | 2.2 | 142 | 14.4 |
| 7. Skilled laborer | 32 | 7.3 | 23 | 4.2 | 55 | 5.6 |
| 8. Professional | 2 | 0.4 | 0 | 0.0 | 2 | 0.2 |
| 9. Property owner | 4 | 0.9 | 5 | 0.9 | 9 | 0.9 |
| 10. Student | 71 | 16.2 | 78 | 14.3 | 149 | 15.1 |
| 11. Housework | 0 | 0.0 | 268 | 49.0 | 268 | 27.1 |
| 12. No occupation | 91 | 20.7 | 56 | 10.2 | 147 | 14.9 |
| Total | 439 | 100.0 | 547 | 100.0 | 986 | 100.0 |

In the control population, the mean age for the males was 20.45 ± 0.37 years, the standard deviation being 16.65 ± 0.26. The mean age among the females was 22.20 ± 0.38, with a standard deviation of 17.10 ± 0.27 years. The difference in the mean ages of the males and the females was 1.75 ± 0.53 in favor of the females. This difference is on the border of being significant.

Among the leper contacts, the mean age for the males was 22.70 ± 0.39, with a standard deviation of 18.0 ± 0.35; while the mean age among the females was 25.15 ± 0.48, with a standard deviation of 18.7 ± 0.34. The above figures indicate that as among the controls, the females were also older than the male population among the contacts, the difference between the two sexes being 2.45 ± 0.606 years.

The males among the leper contacts are on the average older than the males in the control group, the difference in the mean ages being 2.25 ± 0.54 years. The difference in the mean ages of the females in both groups of population was 2.95 ± 0.61, likewise in favor of the contact population.

It may be stated, therefore, that in both sets of population the mean ages of the females were higher than those of the males, while the mean ages of both sexes were higher in the contact group than in the control population.

### OCCUPATION

The occupations of all inhabitants of the two groups who were 10 or more years old are given in Table 5. In two males in the control group, the occupation was not stated in our records; these do not appear in the table. There were slightly more farmers and less fishermen among the leper contacts than in the control population, less skilled or ordinary laborers, somewhat more property owners and students, but also relatively more that had no occupation. None of these differences, however, was significant.

### LITERACY

It was possible to secure literacy data (Table 6) on only 1,230 persons in the control population, and 955 in the leper group. There was more illiteracy in the leper group, the difference in percentages being 9.5 ± 2.13. This difference was even more marked in the rural households surveyed. There were correspondingly fewer who could read and speak English, Spanish, or Visayan among the "contacts."

TABLE 6.—*Literacy, control population, Cebu and Mactan.*

| Language. | Control group.[a] | | | "Leper" group.[b] | | |
|---|---|---|---|---|---|---|
| | Males. | Females. | Total. | Males. | Females. | Total. |
| English and Spanish | 14 | 5 | 19 | 12 | 12 | 24 |
| English and Visayan | 285 | 227 | 512 | 177 | 162 | 339 |
| Spanish and Visayan | 16 | 4 | 20 | 14 | 0 | 14 |
| Visayan only | 97 | 108 | 205 | 62 | 58 | 120 |
| Illiterate | 175 | 299 | 474 | 163 | 295 | 458 |
| Total | 587 | 643 | 1,230 | 428 | 527 | 955 |

[a] Control group: Illiterates, 38.5 per cent; knew English, Spanish, or both, 44.8 per cent; Visayan only, 16.7 per cent.

[b] Leper group: Illiterates, 47.9 per cent; knew English, Spanish, or both, 39.4 per cent; Visayan only, 12.7 per cent.

## MORTALITY

Table 7 gives the number of deaths in the control population, as well as among the contacts to positive lepers, incipient lepers, "paroled negative" lepers, and "total lepers," since the establishment of the family.

The total mortality is lower in the control group than among the "contacts," the death rate among the former being 18.76 $\pm$ 0.8 per hundred of living population, and 26.85 $\pm$ 1.04 per cent among the latter, giving a significant difference of 8.08 $\pm$ 1.35 per cent. It must be remembered that these figures cover an indeterminable number of years and do not represent a yearly or fixed rate. In order to arrive at a more accurate comparison of the rates in the two sets of households, we have worked out the death rate in only one year, that of 1932. It was found to be 12.65 $\pm$ 2.62 per thousand among the control population and 18.28 $\pm$ 3.41 per thousand for the contacts, the difference being 5.53 $\pm$ 4.53, which is not significant. The death rate for the entire province for the corresponding year was 13.81 per thousand.

## INCIDENCE OF LEPROSY

It is not possible to determine the true rate or incidence of leprosy in the present report for obvious reasons. Not until the entire barrio of Baud and the town of Opon have been surveyed will it be possible to estimate the incidence of leprosy in these districts. This inability to determine not only the gross incidence of the disease, but also the true rate by sex, by age groups, by income, etc., has naturally seriously handicapped the proper analysis of the available data in the present report.

TABLE 7.—*Mortality, controls and leper contacts, Mactan and Cebu combined.*[a]

| Age. | Controls. | | | Total lepers. | | | Incipients. | | |
|---|---|---|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | | | | |
| Lest than 1 | 76 | 44 | 120 | 70 | 60 | 130 | 36 | 30 | 66 |
| 1 | 32 | 28 | 60 | 28 | 28 | 56 | 16 | 12 | 28 |
| 2 | 19 | 18 | 37 | 22 | 16 | 38 | 7 | 9 | 16 |
| 3 | 14 | 14 | 28 | 13 | 9 | 22 | 6 | 4 | 10 |
| 4 | 8 | 9 | 17 | 3 | 9 | 12 | 2 | 3 | 5 |
| 5 to 9 | 15 | 27 | 42 | 27 | 26 | 53 | 8 | 9 | 17 |
| 10 to 14 | 6 | 9 | 15 | 12 | 17 | 29 | 3 | 10 | 13 |
| 15 to 19 | 6 | 10 | 16 | 9 | 11 | 20 | 3 | 3 | 6 |
| 20 to 29 | 7 | 6 | 13 | 18 | 9 | 27 | 4 | 1 | 5 |
| 30 to 39 | 7 | 4 | 11 | 8 | 11 | 19 | 3 | 3 | 6 |
| 40 to 49 | 9 | 0 | 9 | 15 | 7 | 22 | 6 | 1 | 7 |
| 50 to 59 | 5 | 2 | 7 | 16 | 4 | 20 | 4 | 1 | 5 |
| 60 to 69 | 9 | 0 | 9 | 6 | 0 | 6 | 3 | 0 | 3 |
| 70 to 79 | 2 | 1 | 3 | 1 | 1 | 2 | 1 | 1 | 2 |
| 80 to 89 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 |
| 90+ | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stillbirths | 14 | 17 | 31 | 15 | 9 | 24 | 0 | 0 | 0 |
| Total | 231 | 191 | 422 | 264 | 218 | 482 | 103 | 88 | 191 |

| Age. | Positives. | | | Paroled. | | |
|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | |
| Less than 1 | 28 | 22 | 50 | 6 | 8 | 14 |
| 1 | 12 | 13 | 25 | 0 | 3 | 3 |
| 2 | 12 | 4 | 16 | 3 | 3 | 6 |
| 3 | 6 | 3 | 9 | 1 | 2 | 3 |
| 4 | 1 | 6 | 7 | 0 | 0 | 0 |
| 5 to 9 | 16 | 15 | 31 | 3 | 2 | 5 |
| 10 to 14 | 6 | 6 | 12 | 3 | 1 | 4 |
| 15 to 19 | 4 | 6 | 10 | 2 | 2 | 4 |
| 20 to 29 | 10 | 7 | 17 | 4 | 1 | 5 |
| 30 to 39 | 3 | 3 | 6 | 2 | 5 | 7 |
| 40 to 49 | 8 | 5 | 13 | 1 | 1 | 2 |
| 50 to 59 | 9 | 3 | 12 | 3 | 0 | 3 |
| 60 to 69 | 2 | 0 | 2 | 1 | 0 | 1 |
| 70 to 79 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 to 89 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 0+ | 0 | 0 | 0 | 0 | 0 | 0 |
| Stillbirths | 13 | 7 | 20 | 2 | 2 | 4 |
| Total | 130 | 100 | 230 | 31 | 30 | 61 |

[a] Total deaths, controls = 422; leper contacts = 482. Total mortality controls = 422 + 1,817 = 2,239. $\frac{422 \times 100}{2,239} = 18.84 \pm 0.8$ per hundred of living population.

Leper contacts = 482 + 1,313 = 1,795. $\frac{482 \times 100}{1,795} = 26.85 \pm 1.04$ per hundred of living population.

Difference = $8.08 \pm 1.35$ per hundred of living population.

## COMPARISON OF CONDITIONS IN CONTROL AND IN LEPER HOUSEHOLDS

In this section, an analysis will be made of the economic and hygienic conditions in both control and "leper" households. By "leper" households or families are meant those in which one or more definite cases of leprosy have developed since their establishment. In other words, the members of such households or families may be considered as "contacts" to the disease, with the exception of those who were born after the case or cases in the household or family had been segregated.

It must be kept in mind that the unit being compared in this section is the "household." Significant differences as to hygienic and economic conditions in the two sets of households will be pointed out, and similarities will be mentioned.

The percentages compared in this report have been tested statistically, although the calculations do not always appear in the text, for the sake of brevity. Whenever the differences are not statistically significant or are merely on the point of being so, these will be mentioned.

Every effort was made to make the data regarding the households surveyed as complete as the circumstances allowed. Directions for filling the blanks in the forms were made as explicit as possible. Four employees of the Cebu Skin Dispensary were assigned to take over the field work but one had to be dropped later. At first, these four, working as a group, were accompanied by both of us to insure uniformity of methods. Later, each worker made the visits accompanied by either one of us until we were sure that the proper procedures were being followed. None of these field workers was assigned to any particular region or to a special class of households. They had other duties to perform besides the survey, and they were sent out as opportunity offered or were shifted about if necessary. Almost all the visits were made on foot.

The work is now so organized that a visit is made to the home of a newly reported case within, at the most, a week after the diagnosis has been made, provided the home can be reached on foot. It is proposed to resurvey the homes and examine as many of the leper households as possibly every six months.

The following discussion is based on the results of the first visits made to the 310 control and 213 leper households already mentioned.

It may be objected that even if the visit to the home of a newly detected leper were made as soon as the diagnosis is arrived at, the conditions in that household at the onset and during the development of the disease might not be the same as at the time the visit was made. Furthermore, the former conditions will never be known; because, due to the long incubation period, the visit is made necessarily from two to five or more years too late. This objection is legitimate only with regard to the first recorded case, but if the visits were made to the same households regularly, say at least once every six months, and new cases developed in some of them, it would then be possible to have an idea of the conditions in these households during the development of the disease.

Although in some cases the households were visited soon after the diagnosis was arrived at, in many others the households were surveyed from one to three years after the lepers had been detected, and in a few cases at even longer intervals. Therefore, these records would seem to be quite useless in many respects; at least, in so far as the previous cases are concerned. Our present data were analyzed chiefly to orientate further work and to find weak points in our present methods of gathering and recording data.

However, the findings proved interesting enough to merit publication of the gross results. Moreover, we believe that the data reflect in a general way the differences, if any, between the control households and the homes where leprosy has occurred.

The analysis of the data covering the following items has been partially completed and will be very briefly presented here.

### KIND OF HOUSE

Houses were classified as to construction as (*a*) bamboo, (*b*) mixed materials, (*c*) wooden, and (*d*) stone and wood.

The size of the house in meters and the number of rooms were determined. The kinds of floor, walls, and roof were recorded and whether the house was owned or rented by the occupant and the amount of rent, if any, were noted. The age of the house was also asked for, and the state of repair was noted. The distance to the main road was estimated, as well as proximity to the sea or a stream. Finally, the ground floor was examined and the use made of it taken down.

Table 8 shows that if the data from Cebu and Mactan are combined, 62.5 per cent of the control households lived in bamboo

houses while only 52.5 per cent of the "leper" households had such houses. Therefore, the leper families seemed to live in more substantial houses than the controls; the difference, however, is not statistically significant. In Opon, there was no difference in the two groups, both having about the same proportion of nipa houses. In Cebu, 64.2 per cent of the controls lived in nipa shacks, while only 42.7 per cent of the houses with cases of leprosy were of similar construction.

TABLE 8.—*Kind of house; Cebu and Mactan combined.*

| Kind of house. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Bamboo | 47 | 51.7 | 46 | 52.3 | 19 | 55.9 | 194 | 62.5 | 112 | 52.5 |
| Mixed material | 17 | 18.7 | 21 | 23.8 | 12 | 35.3 | 66 | 21.3 | 50 | 23.4 |
| Wooden | 15 | 16.5 | 19 | 21.6 | 3 | 8.8 | 47 | 15.2 | 37 | 17.4 |
| Stone and wood | 3 | 3.3 | 0 | 0.0 | 0 | 0.0 | 2 | 0.7 | 3 | 1.4 |
| No data | 9 | 9.9 | 2 | 2.3 | 0 | 0.0 | 1 | 0.3 | 11 | 5.3 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 100.0 | 310 | 100.0 | 213 | 100.0 |

## OVERCROWDING

Overcrowding in the physical sense may be due to excessive nearness of houses to one another or to lack of sufficient space within the houses themselves.

*Nearness of houses to one another.*—Arbitrarily, the house being surveyed was considered "very near" the other houses if it was less than 5 meters to the nearest house. If there were "very near" houses on at least three sides, it was said to be overcrowded; if only on two sides, merely "crowded." If the nearest house was from 5 to 20 meters distant, it was considered "near," while a distance of 20 to 100 meters was called "far" and farther than 100 meters, "isolated."

Table 9 shows that 97.1 per cent of the control houses were not farther than 20 meters from the nearest house, whereas 80.8 per cent of the "leper" houses were similarly situated. The difference was 16.3 $\pm$ 2.84 per cent. Therefore, there was more overcrowding of houses among the "control" than among the "leper" homes, a result not quite expected. In Mactan the difference in this respect was even more marked, as 96.2 per cent of the control houses were within 20 meters of one another, while only 69.5 per cent of the leper homes were found to be as close to the other houses.

TABLE 9.—*Distance to other houses.*

| Distance to other houses. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Overcrowded | 15 | 16.5 | 9 | 10.2 | 0 | 0.0 | 57 | 18.4 | 24 | 11.3 |
| Crowded | 21 | 23.1 | 12 | 13.7 | 0 | 0.0 | 26 | 8.4 | 33 | 15.5 |
| Very near | 18 | 19.8 | 11 | 12.5 | 5 | 14.7 | 36 | 11.6 | 34 | 16.0 |
| Near | 27 | 29.7 | 33 | 37.5 | 21 | 61.8 | 182 | 58.7 | 81 | 38.0 |
| Far | 8 | 8.8 | 15 | 17.0 | 7 | 20.6 | 5 | 1.6 | 30 | 14.1 |
| Isolated | 2 | 2.2 | 8 | 9.1 | 1 | 2.9 | 3 | 1.0 | 11 | 5.1 |
| No data | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.3 | 0 | 0.0 |
| Total | 91 | 100.0 | 88 | 100.0 | 34 | 100.0 | 310 | 100.0 | 213 | 100.0 |

TABLE 10.—*Size of yard.*

| Size of yard. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Very small | 28 | 30.8 | 20 | 22.7 | 8 | 23.5 | 65 | 21.0 | 56 | 26.3 |
| Small | 15 | 16.5 | 12 | 13.7 | 8 | 23.5 | 49 | 15.8 | 35 | 16.4 |
| Medium | 21 | 23.1 | 23 | 26.1 | 8 | 23.5 | 20 | 6.5 | 52 | 24.4 |
| Large | 10 | 11.0 | 12 | 13.7 | 8 | 23.5 | 4 | 1.3 | 30 | 14.0 |
| No fence | 11 | 12.1 | 20 | 22.7 | 2 | 5.9 | 172 | 55.4 | 33 | 15.5 |
| No data | 6 | 6.6 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 | 7 | 3.3 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 99.9 | 310 | 100.0 | 213 | 99.9 |

*Size of yard.*—The degree of congestion is also reflected by the size of the yards about the houses (Table 10). In our survey a yard was considered "very small" if the space not occupied by the house was less than the area covered by the house itself; "small" if it was twice the area of the house; "medium" if three to four times; and "large" if more than four times the space occupied by the house. If there was no fence, this condition was noted.

The table shows that 36.8 per cent of the control houses had "small" and "very small" yards, while in 42.7 per cent of the leper homes they were of about the same size. Therefore, more "leper" homes seemed to have smaller yards; the difference, however, is not significant statistically.

*Number of rooms in house.*—The extent of overcrowding within the house itself is reflected by the number of rooms or partitions in the house. In the numbers of rooms given in Table 11, all subdivisions were included, except the kitchen and the "batalan," or small closets. The "sala" and "comedor" were included.

TABLE 11.—*Number of rooms.*

| Number of rooms. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 1 | 9 | 9.9 | 15 | 17.0 | 6 | 17.7 | 33 | 10.6 | 30 | 14.1 |
| 2 | 28 | 30.8 | 36 | 41.0 | 20 | 58.8 | 74 | 23.9 | 84 | 39.4 |
| 3 | 26 | 28.6 | 19 | 21.6 | 5 | 14.7 | 95 | 30.7 | 50 | 23.4 |
| 4 | 10 | 11.0 | 11 | 12.5 | 2 | 5.9 | 54 | 17.4 | 23 | 10.8 |
| 5 | 3 | 3.3 | 1 | 1.1 | 0 | 0.0 | 23 | 7.4 | 4 | 1.9 |
| 6 | 3 | 3.3 | 1 | 1.1 | 0 | 0.0 | 7 | 2.3 | 4 | 1.9 |
| 7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 2 | 0.6 | 0 | 0.0 |
| 8 | 1 | 1.1 | 1 | 1.1 | 0 | 0.0 | 1 | 0.3 | 2 | 0.9 |
| No data | 11 | 12.1 | 4 | 4.6 | 1 | 2.9 | 21 | 6.8 | 16 | 7.5 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 100.0 | 310 | 100.0 | 213 | 99.9 |

TABLE 12.—*Unit space per adult person.*

| Unit space per person. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Sq. m.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 0 to 3 | 38 | 41.8 | 32 | 36.3 | 16 | 47.0 | 70 | 22.6 | 86 | 40.3 |
| 4 to 7 | 33 | 36.3 | 32 | 36.3 | 14 | 41.4 | 124 | 40.0 | 79 | 37.0 |
| 8 to 11 | 7 | 7.7 | 6 | 6.8 | 2 | 5.9 | 55 | 17.7 | 15 | 7.2 |
| 12 to 15 | 4 | 4.4 | 6 | 6.8 | 1 | 2.9 | 27 | 8.7 | 11 | 5.2 |
| 15+ | 6 | 6.6 | 12 | 13.7 | 1 | 2.9 | 34 | 11.0 | 19 | 8.9 |
| No data | 3 | 3.3 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 | 1.4 |
| Total | 91 | 100.1 | 88 | 99.9 | 34 | 100.0 | 310 | 100.0 | 213 | 100.0 |

The table shows that 34.5 per cent of the control homes had less than three rooms, while 53.5 per cent of the leper houses had less than this number. This shows that in spite of the fact that the houses where leprosy had developed were built of better material than the control homes, they had fewer rooms and that there was more chances of contact between the members of the household.

*Unit space per person.*—Finally, the best way to determine the degree of overcrowding within the house would be to determine the amount of space available for each person. To obtain these data, we measured the area of occupied space in the house (excluding lean-tos, storerooms, etc.), and divided that by the number of persons in the household, taking each individual 10 years or older as one unit and those below this age as one-half. The result then is the amount of space in square meters per adult person in the household. Table 12 gives these data for Cebu and Mactan combined.

It will be noted that in 37.4 per cent of the control households, the members had 8 square meters or more space per person, while only 21.3 per cent of the leper homes had as much space per person. The difference is significant statistically, being 16.1 ± 3.94 per cent. Therefore, there was clearly more overcrowding in the latter homes than in the controls. The results were the same in the urban (Baud) and the rural (Opon) groups.

As the question of overcrowding is obviously important in leprosy, we have endeavored to check the above results by analyzing our available data in a somewhat different manner, using individuals as units rather than households. The total population of the combined leper and control households was ascertained and then subdivided according to the unit space occupied per person. The relative incidence of leprosy was then determined for the various subdivisions. It must be emphasized that the rates thus obtained are useful merely for comparative purposes and should not be considered as the true or actual rates since they are not based on the total population of a given area or district.

TABLE 13.—*Influence of overcrowding on incidence of leprosy.*[a]

| Unit space per person. | Population surveyed. | Cases of leprosy. | Rate per 1,000.[b] |
|---|---|---|---|
| *Sq. m.* | | | |
| 0 to 3 | 1,165 | 122 | 104.7 |
| 4 to 7 | 1,175 | 107 | 91.1 |
| 8 to 11 | 380 | 19 | 50.0 |
| 12 to 15 | 156 | 7 | 44.8 |
| 15+ | 233 | 15 | 64.4 |
| No data | 21 | 0 | ---------- |

[a] These are not true rates, as the population given above is only part of the total population of the area surveyed.

[b] Rate per 1,000 based on population surveyed so far.

Table 13 shows a decided tendency for the incidence of the disease to decrease with an increase in the number of unit spaces per person. The only exception is the last group, in which each of the 233 individuals concerned had more than 15 square meters of available floor space in his home. The reason for this exceptional group is not clear. Many of these individuals lived in small families, hence there was plenty of floor space per individual yet the incidence is higher than that in the group having only 8 to 11 square meters. This exception perhaps

indicates that there are very probably important factors other than overcrowding that influence the occurrence of leprosy in certain households.

Summarizing the differences found in housing conditions among the normal and the "leper" households, we have found that the latter were as a rule housed in better homes, which are not as crowded together as the controls, but that there was more overcrowding within the houses themselves. It should be mentioned in this connection that only when the houses were the same ones lived in by the lepers were they included in the present survey. If the house had been greatly modified since the leper lived in it or since the beginning of his disease, it was not included. Therefore, the objection that conditions during the development of the disease may be entirely different from the conditions at the time of the survey does not hold so much in this matter of the housing.

### AMOUNT OF VEGETATION

It is of interest to know something about the amount of vegetation in the yard about the houses, for if the causative organism in leprosy thrives in the soil, as is suggested by some workers, the amount of shade about the house necessarily exerts some influence on the spread of the disease.

Table 14 indicates that 30.6 per cent of the control houses had little or no vegetation, while 41.8 per cent of the leper homes similarly had scanty vegetation about their homes. This difference is barely statistically significant. In determining the amount of vegetation, the instructions to the field workers were that when there was hardly any vegetation in the yard, it was to be classified as "scanty." When the shadow of the trees and

TABLE 14.—*Amount of vegetation in the yard.*

| Vegetation. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| None | 25 | 27.5 | 10 | 11.3 | 1 | 2.9 | 69 | 22.2 | 36 | 16.9 |
| Scanty | 22 | 24.2 | 22 | 25.0 | 9 | 26.5 | 26 | 8.4 | 53 | 24.9 |
| Slight | 28 | 30.8 | 39 | 44.3 | 22 | 64.7 | 130 | 41.9 | 89 | 41.8 |
| Dense | 8 | 8.8 | 14 | 15.9 | 2 | 5.9 | 80 | 25.8 | 24 | 11.3 |
| Very dense | 2 | 2.2 | 0 | 0.0 | 0 | 0.0 | 1 | 0.3 | 2 | 0.9 |
| No data | 6 | 6.6 | 3 | 3.4 | 0 | 0.0 | 4 | 1.3 | 9 | 4.2 |
| Total | 91 | 100.1 | 88 | 99.9 | 34 | 100.0 | 310 | 99.9 | 213 | 99.9 |

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TABLE 15.—*Number of banana hills and kamungay trees in the yard.*

| Bananas in yard.[a] | | | | | Kamungay in yard.[b] | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hills. | Control households. | | Leper households | | Trees. | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* | | | *P. ct.* | | *P. ct.* |
| 1 to 4 | 50 | 17.5 | 42 | 21.9 | 1 to 4 | 77 | 26.6 | 77 | 39.4 |
| 5 to 9 | 50 | 17.5 | 29 | 15.1 | 5 to 9 | 40 | 13.8 | 29 | 14.8 |
| 10 to 14 | 22 | 7.6 | 17 | 8.9 | 10 to 14 | 17 | 5.9 | 10 | 5.1 |
| 15+ | 30 | 10.4 | 25 | 13.0 | 15+ | 29 | 10.0 | 9 | 4.6 |
| No bananas | 135 | 47.0 | 79 | 41.0 | No trees | 127 | 43.7 | 71 | 36.2 |
| Total | 287 | 100.0 | 192 | 99.9 | Total | 290 | 100.0 | 196 | 100.1 |

[a] Data on number of banana hills were not available for 23 control and 21 leper households.
[b] Data on kamungay trees not available for 20 control and 17 leper households.

TABLE 16.—*Sewage-disposal rating.*

| Sewage-disposal rating. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Less than 20 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 20 to 29 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| 30 to 39 | 8 | 8.8 | 11 | 12.5 | 9 | 26.5 | 19 | 6.1 | 28 | 13.1 |
| 40 to 49 | 22 | 24.2 | 31 | 35.2 | 20 | 58.8 | 183 | 59.0 | 73 | 34.3 |
| 50 to 59 | 9 | 9.9 | 8 | 9.1 | 4 | 11.8 | 43 | 13.8 | 21 | 9.9 |
| 60 to 69 | 20 | 22.0 | 16 | 18.2 | 0 | 0.0 | 7 | 2.3 | 36 | 16.9 |
| 70 to 79 | 15 | 16.5 | 9 | 10.2 | 0 | 0.0 | 30 | 9.7 | 24 | 11.3 |
| 80+ | 16 | 17.6 | 13 | 14.8 | 1 | 2.9 | 28 | 9.0 | 30 | 14.1 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 100.0 | 310 | 99.9 | 213 | 100.1 |

plants about the house at noon covered up to one-fourth of the yard, it was called "slight," "dense" when the shadow covered from one-fourth to three-fourths of the yard, and "very dense" if more than three-fourths of the yard was covered.

Leper homes, if our data mean anything at all, had less vegetation about them than the controls. This finding would hardly be expected if the leprosy germ thrives in the soil and if it is taken for granted that much sunlight is inimical to its growth.

Having observed that the vegetation about many of the houses often included banana and kamungay trees (*Moringa oleifera* Lam.) we decided to obtain data regarding the number of these trees about each house and the consumption of the produce by the household. The young leaves of the kamungay, or horse-radish tree, are universally used as a vegetable by the native people of Cebu and will be discussed more fully under diet.

Each hill of fruit-bearing banana plant was considered as one tree. A kamungay tree was considered "large" when the diameter of the trunk was about 3 or more inches, and "small" when it was less than this. In tabulating, two "small" trees were considered equivalent to one "large" tree.

With regard to the use of the produce, the information obtained as to what proportion was consumed by the household and how much was sold to outsiders was so confusing that it was decided not to discuss it in the present report.

Table 15 gives the number of banana hills and adult kamungay trees in the yard. It is seen that there was practically no difference between the control and the leper households with regard to the number of banana hills. More of the control households (43.7 per cent) than leper homes (36.2 per cent) seemed to have lacked even one kamungay tree, but the difference, 7.5 $\pm$ 2.94 per cent, is not statistically significant.

There were no significant differences, therefore, between the leper and the control homes with regard to the number of kamungay and banana trees in the yards.

### SANITARY CONDITIONS

*Sewage disposal.*—Much difficulty was encountered in arriving at a rating for sewage disposal in many households, especially at Opon, because there were no toilets of any kind. In many cases, the older members of the household simply used swamps or the seashore when these were conveniently close by, or any vacant lot was utilized for the purpose. The children usually defecated in the yard about the house, even if there were surface privies or Antipolo toilets available.

Means of sewage disposal were classified into (*a*) water closets, (*b*) Antipolo system, (*c*) pit system and surface privy, (*d*) defecating anywhere in the yard, and (*e*) defecating in the sea or a stream. The possibility of pollution of the drinking water, the soil, foodstuffs, and contamination by flies, was considered in each case. The system of waste disposal was given a maximum under each of the above headings, and the total was taken as the sewage-disposal rating.

It is seen in Table 16 that 65.1 per cent of the control households had less than a rating of 50 per cent while only 47.9 per cent of the leper homes had as poor methods of waste disposal. Therefore, the leper homes were better off in the matter of sewage disposal than the controls. This difference in favor

of the leper households was particularly marked at Opon; conditions in this respect were more nearly similar in the two sets of households in the city of Cebu.

*Water supply.*—The different sources of water for drinking and household purposes are given below, together with the maximum and minimum percentages allowed for each, unless there was obvious indication of contamination or other sources of error.

| | Per cent. |
|---|---|
| 1. Rain | 60–70 |
| 2. Artesian water | 50–70 |
| 3. Spring | 30–70 |
| 4. Water system | 25–70 |
| 5. Deep well (30 feet or more deep) | 25–70 |
| 6. Shallow well (less than 30 feet deep) | 10–30 |
| 7. Stream (contamination not obvious) | 10–20 |
| 8. Stream (obvious contamination) | 0–10 |

In estimating the final water supply rating, the rate for the source was given a weight of 70 per cent, while the container and handling was allowed 30 per cent.

Table 17 indicates that fully 65.2 per cent of the controls had less than a rate of 50 per cent while but 25.1 per cent of the lepers had the same rating. Therefore, as a general rule, the water supply of the leper households was of better quality than that of the controls. This finding was observed in both the rural and the urban groups.

TABLE 17.—*Water-supply rating.*

| Water-supply rating. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Less than 20 | 1 | 1.1 | 2 | 2.3 | 3 | 8.8 | 1 | 0.3 | 6 | 2.8 |
| 20 to 29 | 1 | 1.1 | 14 | 15.9 | 6 | 17.7 | 62 | 20.0 | 21 | 9.9 |
| 30 to 39 | 9 | 9.9 | 8 | 9.1 | 5 | 14.7 | 110 | 35.5 | 22 | 10.3 |
| 40 to 49 | 4 | 4.4 | 6 | 6.8 | 3 | 8.8 | 29 | 9.4 | 13 | 6.1 |
| 50 to 59 | 9 | 9.9 | 8 | 9.1 | 7 | 20.6 | 3 | 1.0 | 24 | 11.3 |
| 60 to 69 | 17 | 18.7 | 17 | 19.3 | 6 | 17.7 | 13 | 4.2 | 40 | 18.8 |
| 70 to 79 | 20 | 22.0 | 17 | 19.3 | 1 | 2.9 | 39 | 12.6 | 38 | 17.8 |
| 80+ | 30 | 33.0 | 16 | 18.2 | 3 | 8.8 | 53 | 17.1 | 49 | 23.0 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 100.0 | 310 | 100.1 | 213 | 100.0 |

*Sanitary control.*—The rate was based on the number of mice, bedbugs, flies, cockroaches, and mosquitoes found in the house, as well as the number of loose animals, as pigs, chickens, goats,

dogs, etc., about the house. This rating was found to be exceptionally difficult, or practically impossible, to calculate because of the time necessary to confirm the presence of bedbugs, mice, etc., and the reluctance of the people to allow the field workers to examine their larders for cockroaches, and mats and pillows for bedbugs, etc. In most of the cases, the workers had to depend largely on statements voluntarily supplied by the housewife herself.

TABLE 18.—*Sanitary-control rating.*

| Sanitary-control rating. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Less than 20 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 6 | 2.0 | 0 | 0.0 |
| 20 to 29 | 2 | 2.2 | 1 | 1.1 | 0 | 0.0 | 8 | 2.6 | 3 | 1.4 |
| 30 to 39 | 4 | 4.4 | 11 | 12.5 | 7 | 20.3 | 50 | 16.1 | 22 | 10.3 |
| 40 to 49 | 30 | 33.0 | 22 | 25.0 | 9 | 26.7 | 71 | 22.9 | 61 | 28.6 |
| 50 to 59 | 30 | 33.0 | 25 | 28.4 | 9 | 26.7 | 89 | 28.7 | 64 | 30.0 |
| 60 to 69 | 20 | 22.0 | 20 | 22.7 | 7 | 20.3 | 65 | 21.0 | 47 | 22.1 |
| 70 to 79 | 5 | 5.5 | 8 | 9.1 | 2 | 5.9 | 17 | 5.5 | 15 | 7.0 |
| 80+ | 0 | 0.0 | 1 | 1.1 | 0 | 0.0 | 4 | 1.3 | 1 | 0.5 |
| Total | 91 | 100.1 | 88 | 99.9 | 34 | 99.9 | 310 | 100.1 | 213 | 99.9 |

TABLE 19.—*Cleanliness rating.*

| Cleanliness rating. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Less than 20 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 20 to 29 | 0 | 0.0 | 1 | 1.1 | 0 | 0.0 | 1 | 0.3 | 1 | 0.5 |
| 30 to 39 | 8 | 8.8 | 8 | 9.1 | 7 | 20.3 | 5 | 1.6 | 23 | 10.8 |
| 40 to 49 | 12 | 13.2 | 19 | 21.6 | 9 | 26.7 | 40 | 12.9 | 40 | 18.8 |
| 50 to 59 | 13 | 14.3 | 18 | 20.5 | 9 | 26.7 | 111 | 35.8 | 40 | 18.8 |
| 60 to 69 | 23 | 25.3 | 22 | 25.0 | 7 | 20.3 | 87 | 28.0 | 52 | 24.4 |
| 70 to 79 | 23 | 25.3 | 12 | 13.7 | 2 | 5.9 | 58 | 18.7 | 37 | 17.4 |
| 80+ | 12 | 13.2 | 7 | 7.9 | 0 | 0.0 | 8 | 2.6 | 19 | 8.9 |
| No data | 0 | 0.0 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 99.9 | 310 | 99.9 | 213 | 100.1 |

According to Table 18, the control households had a rating of less than 50 per cent in 43.6 per cent of the cases, while 40.3 per cent of the leper homes had a rating as poor as this. There seems to be a slight advantage in favor of the leper households, but the difference is not significant.

*Cleanliness.*—This rate depends on the cleanliness of the home and of the individual members of the household. The weights

given to the different items entering into the determination of this rate were as follows:

| | Maximum per cent. |
|---|---|
| Living and bed rooms | 25 |
| Dining room and kitchen | 25 |
| Yard | 25 |
| Personal cleanliness | 25 |

The total was taken as the rating for cleanliness. It is demonstrated in Table 19 that whereas only 14.8 per cent of the controls had a rating of less than 50 per cent, 30.1 per cent of the leper household had such a rating. This indicates that more of the households where lepers had previously lived or were living were dirty compared to the normal controls. This observation is quite remarkable in view of the fact that the majority of the leper homes were built with better and stronger materials, and as we shall mention later, the average earning capacity in both groups is about the same.

*General sanitary rating.*—In their epidemiologic study on pellagra in the southern portion of the United States, Goldberger, Wheeler, and Sydenstriker, aided by Barber,[2] used the general sanitary rating devised by Frost in his extensive epidemiologic survey of the Mississippi Valley some years previously, to determine the sanitary condition of the households surveyed. As he was investigating chiefly for acute waterborne infections, Frost naturally gave preponderating weight to the purity of the water supply. We believe that in the study of a disease like leprosy such a standard of general sanitary rating is not applicable.

In the absence of better knowledge regarding the transmission of the disease, we have simply taken the average of the ratings for sewage disposal, water supply, sanitary control, and cleanliness, and considered this as the general sanitary rating, thereby giving equal weight to these four sanitary items.

The result is shown in Table 20 where it is seen that while only 8.1 per cent of the control households have a general sanitary rating of 70 per cent or better, 13.6 per cent of the leper homes have a corresponding rating, indicating that the latter have a better sanitary average than the former. This result is to be expected in view of the advantage shown by the leper

[2] Public Health Reports 35 (1920) 1701–1714.

homes with regard to sewage disposal, water supply, and sanitary control, although the advantage is decidedly on the side of the controls in the matter of home and personal cleanliness.

These observations suggest that in adopting a standard for general sanitary rating in the epidemiologic study of leprosy, more weight should be given to cleanliness than to the other items, such as waste disposal, water supply, and perhaps even sanitary control, although the last needs to be further investigated.

TABLE 20.—*General sanitary rating.*

| General-sanitary rating. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Less than 20 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 20 to 29 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| 30 to 39 | 0 | 0.0 | 6 | 6.8 | 6 | 17.7 | 31 | 10.0 | 12 | 5.6 |
| 40 to 49 | 18 | 19.8 | 25 | 28.4 | 14 | 41.4 | 133 | 42.9 | 57 | 26.8 |
| 50 to 59 | 26 | 28.6 | 27 | 30.7 | 11 | 32.4 | 67 | 21.6 | 64 | 30.0 |
| 60 to 69 | 30 | 33.0 | 18 | 20.5 | 2 | 5.9 | 54 | 17.4 | 50 | 23.4 |
| 70 to 79 | 15 | 16.5 | 9 | 10.2 | 1 | 2.9 | 21 | 6.8 | 25 | 11.7 |
| 80+ | 1 | 1.1 | 3 | 3.4 | 0 | 0.0 | 4 | 1.3 | 4 | 1.9 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 100.0 | 310 | 100.0 | 213 | 99.9 |

TABLE 21.—*Presence and size of pusali.*

| Pusali. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Very small | 23 | 25.3 | 15 | 17.0 | 2 | 5.9 | 33 | 10.6 | 40 | 18.8 |
| Small | 19 | 20.9 | 18 | 20.5 | 6 | 17.7 | 16 | 5.1 | 43 | 20.2 |
| Large | 9 | 9.9 | 4 | 4.6 | 1 | 2.9 | 7 | 2.3 | 14 | 6.6 |
| None | 38 | 41.8 | 50 | 56.8 | 25 | 73.5 | 254 | 82.0 | 113 | 53.0 |
| No data | 2 | 2.2 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 | 3 | 1.4 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 100.0 | 310 | 100.0 | 213 | 100.0 |

TABLE 22.—*Use of soap.*

| Frequency. | Control households. | | Leper households. | | Total. |
|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | |
| Always | 173 | 56.7 | 112 | 52.6 | 285 |
| Usually | 37 | 12.1 | 18 | 8.5 | 55 |
| Sometimes | 89 | 29.2 | 78 | 36.6 | 167 |
| Never | 6 | 2.0 | 5 | 2.3 | 11 |
| Total | 305 | 100.0 | 213 | 100.0 | 518 |

TABLE 23.—*Frequency of bathing among adults.*

| Frequency. | Control households. | | Leper households. | | Total. |
|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | |
| Daily | 23 | 7.5 | 16 | 7.5 | 39 |
| Almost daily | 122 | 40.0 | 88 | 41.3 | 210 |
| Twice a week | 149 | 48.9 | 57 | 26.8 | 206 |
| Less than twice a week | 11 | 3.6 | 52 | 24.4 | 63 |
| Total | 305 | 100.0 | 213 | 100.0 | 518 |

TABLE 24.—*Frequency of bathing among children.*

| Frequency. | Control households. | | Leper households. | | Total. |
|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | |
| Daily | 26 | 10.5 | 29 | 15.3 | 55 |
| Almost daily | 107 | 43.3 | 83 | 43.6 | 190 |
| Twice a week | 105 | 42.5 | 36 | 19.0 | 141 |
| Less than twice a week | 9 | 3.6 | 42 | 22.1 | 51 |
| Total | 247 | 99.9 | 190 | 100.0 | 437 |

*Pusali.*—An indication of the cleanliness or proper health habits of a household in the Philippines is the presence or absence, and if present, the size and condition, of what is known as "pusali" among Tagalogs and "panghugasan" among Cebuanos. In many Filipino homes, there is a small extension of the kitchen known in many parts of the Islands as "batalan" and called locally "pantao." Usually, it is not roofed and the flooring is of bamboo or of young saplings set apart, so as to allow better drainage and to facilitate drying. All the dish washing and scouring of pots, as well as the washing of the feet and hands, is done in the batalan. In clean homes the wash water, which accumulates under the batalan, is drained away or a pile of stones is built underneath in order to prevent chickens from scratching up the wet soil and loose pigs from wallowing there during the hot part of the day. Unless care is thus taken, the place is converted into a dirty mudhole, which is the "pusali," and in very careless households, the stench is perceptible even to the casual visitor in the "sala," or receiving room.

Table 21 shows that in 82.0 per cent of the control homes, there was no pusali, while only 53.0 per cent of leper households

did not have it. This finding again would tend to show that leper homes are less cleanly than the controls.

*Frequency of bathing and the use of soap.*—Data regarding these points are given in Tables 22, 23, and 24. It should be remembered that the figures appearing in these tables represent the average frequency of bathing and use of soap for the family or household as a whole and not that of individuals. They are based on the statements of the informant in each household, the only check being the general appearance of the members of the household.

TABLE 25.—*Number of persons in household (size of family).*

| Persons. | Incipients. | | Positives. | | Paroled. | | Total controls. | | Total contacts. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 1 to 2 | 1 | 1.1 | 9 | 10.2 | 2 | 5.9 | 32 | 10.3 | 12 | 5.6 |
| 3 to 4 | 14 | 15.4 | 23 | 26.1 | 8 | 23.6 | 84 | 27.1 | 45 | 21.1 |
| 5 to 6 | 26 | 28.6 | 16 | 18.2 | 9 | 26.4 | 76 | 24.5 | 51 | 23.9 |
| 7 to 8 | 17 | 18.7 | 25 | 28.4 | 6 | 17.4 | 61 | 19.7 | 48 | 22.5 |
| 9 to 10 | 20 | 22.0 | 9 | 10.2 | 8 | 23.6 | 36 | 11.6 | 37 | 17.4 |
| 11 to 12 | 9 | 9.9 | 4 | 4.5 | 1 | 2.9 | 13 | 4.2 | 14 | 6.6 |
| 13 to 14 | 1 | 1.1 | 1 | 1.1 | 0 | 0.0 | 6 | 1.9 | 2 | 0.9 |
| 15 to 16 | 2 | 2.2 | 1 | 1.1 | 0 | 0.0 | 1 | 0.3 | 3 | 1.4 |
| 17 to 18 | 1 | 1.1 | 0 | 0.0 | 0 | 0.0 | 1 | 0.3 | 1 | 0.5 |
| 19+ | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Total | 91 | 100.1 | 88 | 99.9 | 34 | 100.0 | 310 | 99.9 | 213 | 99.9 |

TABLE 26*a*.—*Classification of total income of control and leper households by "adult male units."*

| Income per adult male unit. | Households. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Incipients. | | Positives. | | Paroled. | | Total controls | | Total contacts. | |
| *Pesos.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Less than 20 | 5 | 5.5 | 12 | 13.7 | 10 | 29.4 | 13 | 4.2 | 27 | 12.7 |
| 20 to 39 | 18 | 19.8 | 19 | 21.6 | 11 | 32.3 | 51 | 16.5 | 48 | 22.5 |
| 40 to 59 | 11 | 12.1 | 16 | 18.2 | 3 | 8.8 | 56 | 18.1 | 30 | 14.1 |
| 60 to 79 | 10 | 11.0 | 6 | 6.8 | 2 | 5.9 | 44 | 14.2 | 18 | 8.4 |
| 80 to 99 | 7 | 7.7 | 6 | 6.8 | 5 | 14.7 | 43 | 13.8 | 18 | 8.4 |
| 100 to 119 | 7 | 7.7 | 8 | 9.1 | 3 | 8.9 | 25 | 8.0 | 18 | 8.4 |
| 120 to 139 | 8 | 8.8 | 3 | 3.4 | 0 | 0.0 | 21 | 6.8 | 11 | 5.2 |
| 140 to 159 | 11 | 12.1 | 3 | 3.4 | 0 | 0.0 | 19 | 6.1 | 14 | 6.6 |
| 160 to 179 | 1 | 1.1 | 2 | 2.3 | 0 | 0.0 | 8 | 2.6 | 3 | 1.4 |
| 180 to 199 | 3 | 3.3 | 1 | 1.1 | 0 | 0.0 | 8 | 2.6 | 4 | 1.9 |
| 200+ | 10 | 11.0 | 12 | 13.6 | 0 | 0.0 | 22 | 7.1 | 22 | 10.3 |
| Total | 91 | 100.1 | 88 | 100.0 | 34 | 100.0 | 310 | 100.0 | 213 | 99.9 |

TABLE 26b.—*Comparative rate of leprosy per thousand of population classified according to income based on "adult male units."*[a]

| Income per adult male unit. | Population surveyed. | Lepers. | Rate per 1,000.[b] |
|---|---|---|---|
| *Pesos.* | | | |
| Less than 40 | 848 | 117 | 137.9 |
| 40 to 79 | 970 | 56 | 57.7 |
| 80 to 119 | 573 | 41 | 71.5 |
| 120 to 159 | 345 | 25 | 72.4 |
| 160 to 199 | 140 | 9 | 61.4 |
| 200+ | 254 | 22 | 86.6 |

[a] This is not the true rate as the population given above is only that of a small portion of the area to be surveyed.

[b] Rate per thousand based on population surveyed.

TABLE 27.—*Regularity of rice, corn, and a mixture of both in the main diet of control and leper households.*

| Presence at table. | Rice. | | | | Corn. | | | |
|---|---|---|---|---|---|---|---|---|
| | Control households. | | Leper households. | | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Never | 14 | 4.5 | 7 | 3.3 | 16 | 5.2 | 18 | 8.5 |
| Very seldom | 102 | 32.9 | 16 | 7.5 | 4 | 1.3 | 3 | 1.4 |
| Seldom | 128 | 38.7 | 127 | 59.6 | 35 | 11.1 | 46 | 21.6 |
| Often | 58 | 18.7 | 62 | 29.1 | 58 | 18.7 | 128 | 60.0 |
| Frequently | 5 | 1.6 | 0 | 0.0 | 3 | 1.0 | 18 | 8.5 |
| Regularly | 11 | 3.5 | 1 | 0.5 | 194 | 62.6 | 0 | 0.0 |
| Total | 318 | 99.9 | 213 | 100.0 | 310 | 99.9 | 213 | 100.0 |

| Presence at table. | Mixture of rice and corn. | | | |
|---|---|---|---|---|
| | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* |
| Never | 99 | 32.0 | 55 | 25.8 |
| Very seldom | 83 | 26.8 | 12 | 5.6 |
| Seldom | 76 | 24.5 | 126 | 59.1 |
| Often | 35 | 11.3 | 20 | 9.4 |
| Frequently | 7 | 2.2 | 0 | 0.0 |
| Regularly | 10 | 3.2 | 0 | 0.0 |
| Total | 310 | 100.0 | 213 | 99.9 |

The only striking observation brought out in Tables 23 and 24 is that whereas only 3.6 per cent of the control households admit that the adult members take a bath less often than twice a week, 24.4 per cent of the leper homes admit such extreme infrequency of bathing, while among the children, the corre-

sponding figures are 3.6 per cent and 22.1 per cent, respectively. These differences are statistically significant. In the use of soap, there were no differences, as can be noted in Table 22.

### SIZE OF THE FAMILY

It has already been shown that on the average, the households where leprosy has occurred were larger than the controls. This is also demonstrated in Table 25, which indicates that only 18.3 per cent of the control households had more than eight persons while 26.8 per cent of the leper households had that number.

### FAMILY INCOME

It must be admitted that our data on family income were based chiefly on the statements of the most responsible member of the household, but this was carefully checked by inquiring for the amount of property and other taxes paid, and especially at Opon, by estimating the amount of produce that might be expected from their land. A schedule was drawn up with the help of the municipal president, in which the average yield of corn, sweet potatoes, cassava, maguey, etc., per year per hectare of land was estimated, and the minimum production of coco, banana, and other fruit trees, etc., per year per plant was also arrived at. An arbitrary yearly income was also charged per head of productive cattle, pigs, goats, turkeys, and chickens owned by the family. We believe that the figures set down were not very far from the real family income, which in many cases the owners did not know themselves.

In epidemiologic studies where data on the family income are required, difficulty is always met in classifying the income. In the first place, it is necessary to consider the size of the family or household. Of two poor families that receive about the same income more suffering and unfavorable hygienic conditions are likely to be found in the larger family. Of course, the expenditure of a family composed chiefly of males differs somewhat from one in which the majority are females. Also, much depends on the manner in which the money is spent; whereas one family may be able to live decently and may even save a little on a small income, another of the same size and composition may be practically on the border line of starvation earning the same amount.

In order to overcome the differences in the age and sex constitution of unequal family groups, Goldberger, Wheeler, and

Sydenstriker(3), in their epidemiologic studies on pellagra already referred to, decided to—

> . . . employ a common denominator to which the individuals of both sexes and of all ages could be reduced in order to obtain a more accurately representative method of expressing the relative size of the families to be compared.
>
> In the absence of a better common denominator for this purpose, the Atwater (1915) scale of food requirements was employed, and the size of each family was computed according to this scale and expressed in terms of "adult male units". The assumption in the use of this scale was that the expenditures for total maintenance for individuals varied according to sex and age in the same proportion as did their food requirements. The assumption is by no means as accurate as could be desired; in its favor, however, it may be said that since family expenditures in the great majority of cases equaled total family income, and since food expenditures were nearly half (among poorer families considerably more than half) of total expenditures, a scale based on food requirements alone is obviously very much more accurate than one omitting any consideration whatsoever of the number, sex, and age of the individuals composing the families to be compared with respect to income. For the present purpose, therefore, the total income of each family . . . has been divided by the number of "adult male units" subsisting on the family income, and the resulting figure has been termed the "family income per adult male unit."

The scale used by them, based on the Atwater scale, was as follows:

| Age. | Equivalent adult male unit. | |
|---|---|---|
| | Male. | Female. |
| *Years.* | | |
| Adult (over 16) | 1.0 | 0.8 |
| 15 to 16 | 0.9 | 0.8 |
| 13 to 14 | 0.8 | 0.7 |
| 12 | 0.7 | 0.6 |
| 10 to 11 | 0.6 | 0.6 |
| 6 to 9 | 0.5 | 0.5 |
| 2 to 5 | 0.4 | 0.4 |
| Under 2 | 0.3 | 0.3 |

We adopted the same method in our survey and the results are shown in Table 26*a*. It is seen in this table that the income of the control and that of the leper families differ in certain significant details, but these differences are not as great as they may seem. This will be appreciated if the data are simplified as follows:

| Income per adult male unit. | Control families. | "Leper" families. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Incomes less than 100 pesos per unit | 66.8 | 66.1 |
| Incomes more than 100 pesos per unit | 33.2 | 33.8 |

However, it is apparent in Table 26*a* that a significantly larger proportion of "leper" or "contact" households earned less than 40 pesos per adult male unit per year, than the controls (difference $= 12.5 \pm 3.96$ per cent).

We have attempted also to analyze the data on the income by using the individuals rather than the households as units. In other words, the total population of the control and of the leper households were combined and then grouped according to the income expressed in adult male units of the families to which they belonged, and the incidence of leprosy in these groups was determined. The result is given in Table 26*b*.

Table 26*b* shows no tendency for the incidence of the disease to diminish with increase in the income, although the incidence is higher in the group with the lowest income per unit than in any of the other groups. It should be remembered that the rates recorded in Table 26*b* are not actual or real rates of the disease, because they are not based on the total population of a given district. They are useful merely for comparative purposes.

It may be adduced from the data discussed very briefly in the preceding pages that families in which leprosy had developed in Cebu Province when compared with nonleper households belonging to approximately the same social and economic status, lived in comparatively better houses, had as good or even better means of sewage disposal and safer water supply, but were larger, more overcrowded within their homes, and less cleanly in their personal habits and surroundings, than the control families.

It is important to remember, however, that both the control and the leper households belong to the poorer or possibly the poorest classes in Cebu Province. When the population of the province is taken as a whole, the disease will be found to attack chiefly the poorest households.

Attention is also called to the fact that in age and sex distribution, as well as in occupation and family income, the control and the leper families were very similar if the rural and urban

groups are combined together. This proves that the selection of our control population was fairly successful in spite of serious limitations affecting the present survey.

### DIET

The diet of the Cebuanos and other Visayan peoples has not been as well studied as that of the people around Manila. The Cebuano diet differs from that of the rest of the Archipelago in certain important aspects.

1. The principal grain is corn instead of rice, the latter being considered a luxury.

2. The young leaves of the kamungay tree is the commonest vegetable consumed. This vegetable is occasionally eaten by the Ilocanos, and it is practically unknown among the Tagalogs; in Cebu it is used almost daily by the poor people.

3. Since all the towns in the province are located along the seashore, the central portions of the very narrow island being mountainous and hardly habitable, fish is extensively used by practically the entire population. Among the laboring and farming classes, fish is commonly eaten in preserved form, either as "guinamus" (which is merely salted fish, often in some degree of decomposition) or as dried fish.

Corn is commonly used as a finely ground meal. In milling, the germ is removed to increase its keeping qualities. White corn is much more generally used than the yellow variety.

Corn approaches wheat in protein value, and has the same mineral deficiencies as the latter; namely, shortage of calcium, phosphorus, sodium, and chlorine, in sufficient quantities to maintain growth. It has a slightly higher caloric value than rice, and seems to be a better source of vitamin B. Beriberi is much rarer in Cebu than in Luzon.

Although corn is the basic diet of the Cebuanos, rice seems to be considered more palatable by most of them. Hospitalized lepers refuse to eat corn when rice is available. In the course of the present survey, we found that some of the poorest families sometimes bought rice and this was cooked either mixed with corn meal or alone. When this was done, however, a corresponding saving on fish and vegetables had to be made to offset the higher cost of the rice.

We have endeavored in the present survey to ascertain the frequency with which certain food items were served at the family table. When a particular item was consumed by most

of the people in the household daily or almost daily, it was considered to have been eaten "regularly." If it was served oftener than twice a week but less often than daily (say, three or four times a week), it was considered to have been eaten "frequently." If it was eaten every week or so (oftener than twice a month and less often than twice a week), the regularity was classified as "often." If an article of food was served less often than twice a month, it was considered as "seldom" eaten; if it appeared on the table only very occasionally (say, a few times a year), it was considered "very seldom" partaken of. If it had not been served as long as the informants could remember, then it was considered "never" eaten by the family.

This method of investigating the diet is naturally open to serious objections, three of which need to be mentioned here:

(*a*) This method fails to show the biologic and caloric value of the food eaten by the people under study.

(*b*) It does not indicate the consumption of the different individuals in the household.

(*c*) The data obtained are based almost entirely on information voluntarily furnished by the people in the household.

Also, with reference to the first objection, it must be mentioned that no biologic analyses have been made of many of the articles of food used in Cebu, particularly as regards the principal vegetables and the kinds of fishes eaten. It is planned to study somewhat more intensively the diet of a few representative control and leper households. The present method was used in the preliminary study merely because it was the best that could be devised with the resources available to us.

With regard to the consumption of rice and corn, the striking feature brought out in the present survey is shown in Table 27. Among households under very closely similar poor financial conditions, the leper households ate rice more commonly than the control households. It is seen in the rice column that 37.4 per cent of the control households never or very seldom ate rice, while only 10.8 per cent of the leper households ate it as seldom as that. The difference between these percentages is $26.6 \pm 2.37$. On the other hand, 63.6 per cent of the control families ate corn daily or almost every day, while only 8.5 per cent of the leper household ate corn as frequently. It may be concluded from the above analysis that the majority of leper households tried to eat rice as often as possible, at least more frequently than the control households. We have learned that practically every

time that rice is eaten among the poor people, less fish and vegetables are bought as rice is more expensive locally than corn. It has already been pointed out that their income is too limited to permit such luxury.

Data with respect to tubers, such as "gabi," or taro, and "ubi," etc., as well as to kamungay and other vegetables, are shown in Table 28. There is a tendency to eat tubers more frequently among the leper families than among the control households.

TABLE 28.—*Frequency of tubers, kamungay, and other vegetables on the table of control and leper families.*

| Frequency at table. | Tubers. | | | | Kamungay. | | | |
|---|---|---|---|---|---|---|---|---|
| | Control households. | | Leper households. | | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Never | 13 | 4.2 | 4 | 11.9 | 6 | 1.9 | 1 | 0.5 |
| Very seldom | 106 | 34.2 | 20 | 9.4 | 3 | 1.0 | 1 | 0.5 |
| Seldom | 140 | 45.2 | 95 | 44.5 | 37 | 12.0 | 72 | 33.8 |
| Often | 41 | 13.2 | 91 | 42.8 | 135 | 43.5 | 132 | 62.0 |
| Frequently | 6 | 1.9 | 2 | 0.9 | 64 | 20.6 | 3 | 1.4 |
| Regularly | 4 | 1.3 | 1 | 0.5 | 65 | 21.0 | 4 | 1.9 |
| Total | 310 | 99.9 | 213 | 100.0 | 310 | 99.9 | 213 | 100.0 |

| Frequency at table. | Other vegetables. [a] | | | |
|---|---|---|---|---|
| | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* |
| Never | 4 | 1.6 | 6 | 4.0 |
| Very seldom | 1 | 0.4 | 0 | 0.0 |
| Seldom | 48 | 18.8 | 82 | 54.2 |
| Often | 109 | 42.5 | 59 | 39.0 |
| Frequently | 71 | 27.8 | 3 | 2.0 |
| Regularly | 23 | 9.0 | 1 | 0.7 |
| Total | 310 | 100.0 | 213 | 99.9 |

[a] No data regarding eating of "other vegetables" available for 54 control and 62 leper households.

It has been mentioned elsewhere in this report that the young leaves of the kamungay tree (*Moringa oleifera* Lam.) constitute the main leafy vegetable of the people of Cebu. Many poor families eat nothing but boiled kamungay leaves, with or without salted, dried, or fresh fish, three times a day with their corn for months at a time. So far as we are aware, the vitamin content of kamungay leaves has not been determined, although this vegetable was examined chemically long ago by Agcaoili,

who reported that it contained 7.29 per cent protein, the highest in any of the leafy vegetables studied at the time.[4] The biologic value of the protein was not determined. Agcaoili also found the cost of 1 kilo of protein in kamungay leaves much lower than in any other leafy vegetable studied by him.

Recently, this vegetable was found to be an excellent source of calcium and iron by Marañon, of the Bureau of Science. The result of his chemical analysis, heretofore unpublished, is as follows:

*Leaves of kamungay, Moringa oleifera Lam.*

| | Per cent. |
|---|---|
| Ash: | |
| Fresh sample | 2.84 |
| Moisture-free sample | 13.64 |
| Phosphorus ($P_2O_5$): | |
| Fresh sample | 0.24 |
| Moisture-free sample | 1.16 |
| Calcium (CaO): | |
| Fresh sample | 0.72 |
| Moisture-free sample | 3.47 |
| Iron ($Fe_2O_3$): | |
| Fresh sample | 0.108 |
| Moisture-free sample | 0.52 |

Dr. A. J. Hermano, of the Bureau of Science, has also found the leaves to be a good source of vitamins A and $B_1$. This vegetable is believed to stimulate the flow of human milk and it is extensively used by lactating mothers around Manila.

Referring to Table 28, it is seen that 41.6 per cent of control households ate kamungay leaves almost every day, as contrasted with only 3.3 per cent of the leper households. With regard to leafy vegetables other than kamungay, 37.8 per cent of control against 2.7 per cent of leper households, ate them as often as three or four times a week or oftener. There seems to be no doubt, then, that the majority of households in which leprosy has appeared ate less leafy vegetables than those in which the disease is unknown.

The next table (Table 29) indicates that while 39.0 per cent of the control families stated that they never or very seldom ate dried fish, only 9.9 per cent of leper families claimed to have eaten dried fish so infrequently. On the other hand, 23.6 per cent of the controls, as against 11.7 per cent of the leper households, ate dried fish at least twice a month or oftener. The

[4] Census of the Philippine Islands. Manila 3 (1918) 917–27.

large majority of the latter households admitted eating this particular food only every week or so.

Curiously, more of the control households ate guinamus, or salted fish, regularly, while raw shellfish were more frequently eaten by the leper households (Table 29).

TABLE 29.—*Frequency of dried fish, salted fish (guinamus), and raw shellfish in the diet of leper and control households.*

| Frequency at table. | Dried fish. | | | | Salted fish. | | | |
|---|---|---|---|---|---|---|---|---|
| | Control households. | | Leper households. | | Control households. | | Leper households. | |
| | | P. ct. | | P. ct. | | P. ct. | | P. ct. |
| Never | 10 | 3.2 | 4 | 1.9 | 11 | 3.5 | 9 | 4.2 |
| Very seldom | 111 | 35.8 | 17 | 8.0 | 57 | 18.4 | 25 | 11.7 |
| Seldom | 116 | 37.4 | 166 | 78.0 | 143 | 46.2 | 153 | 71.8 |
| Often | 65 | 21.0 | 25 | 11.7 | 90 | 29.0 | 21 | 9.9 |
| Frequently | 4 | 1.3 | 0 | 0.0 | 4 | 1.3 | 3 | 1.4 |
| Regularly | 4 | 1.3 | 1 | 0.5 | 5 | 1.6 | 2 | 0.9 |
| Total | 310 | 100.0 | 213 | 100.1 | 310 | 100.0 | 213 | 99.9 |

| Frequency at table. | Raw shellfish.[a] | | | |
|---|---|---|---|---|
| | Control households. | | Leper households. | |
| | | P. ct. | | P. ct. |
| Never | 79 | 26.0 | 53 | 25.4 |
| Very seldom | 155 | 51.1 | 41 | 19.6 |
| Seldom | 58 | 19.2 | 106 | 50.7 |
| Often | 11 | 3.6 | 9 | 4.3 |
| Frequently | 0 | 0.0 | 0 | 0.0 |
| Regularly | 0 | 0.0 | 0 | 0.0 |
| Total | 303 | 99.9 | 209 | 100.0 |

[a] In 7 control and 4 leper homes, no data were available as to frequency of raw shellfish at the family table.

Fish is an important element in the diet of the Cebuanos. Edible fish are commonly divided in the minds of the people into those that are "malansa," or too fishy, and those that are not so. The malansa kinds include *halwan, danguit, pata, ubod indong, bunog, ugapon, barungoy, tagutuñgán, kadlitan, awá, ihó, indangan,* and some varieties of *molmol.*

Raw fish is apparently not regularly eaten in Cebu, according to the figures shown in Table 30, but it is certainly more frequently indulged in by the leper households than by the controls. On the other hand, the control families ate cooked fish, both of the malansa and the nonmalansa varieties, more regularly than the other group.

Table 31 gives some information as to the consumption of pork, beef and chicken, and milk. Very few families (less than 1 per cent except for pork which is eaten somewhat more frequently) eat meat or meat products regularly. There was no significant difference in the consumption of these items in the two groups of households. Milk was very little used by the inhabitants under study, only about 10 per cent of the families claiming that they drank milk as often as once a week, and very probably in small amounts at that.

Finally, Table 32 confirms that part of the findings of those who have investigated the diet of Filipino families which indicates that fruits and sweets are seldom eaten among our people, at least, in connection with their meals. Less than 10 per cent of the households in both groups ate fruit and "dulces" as frequently as once a week, either during or after their meals, and only 2 families out of 481 stated that they had fruit or dulce,

TABLE 30.—*Regularity of raw fish and of cooked "malansa" and "not malansa" fish in the diets of leper and non-leper households.*

| Frequency at table. | Raw fish. [a] | | | | Cooked fish, malansa. | | | |
|---|---|---|---|---|---|---|---|---|
| | Control households. | | Leper households. | | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Never | 186 | 68.4 | 57 | 26.8 | 45 | 14.5 | 38 | 17.9 |
| Very seldom | 46 | 16.9 | 62 | 29.0 | 33 | 10.6 | 38 | 17.9 |
| Seldom | 33 | 12.1 | 92 | 43.2 | 98 | 31.6 | 118 | 55.3 |
| Often | 7 | 2.6 | 2 | 0.9 | 78 | 25.2 | 19 | 8.9 |
| Frequently | 0 | 0.0 | 0 | 0.0 | 34 | 11.0 | 0 | 0.0 |
| Regularly | 0 | 0.0 | 0 | 0.0 | 22 | 7.1 | 0 | 0.0 |
| Total | 272 | 100.0 | 213 | 99.9 | 310 | 100.0 | 213 | 100.0 |

| Frequency at table. | Cooked fish, not malansa. [b] | | | |
|---|---|---|---|---|
| | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* |
| Never | 0 | 0.0 | 5 | 2.5 |
| Very seldom | 1 | 0.3 | 6 | 3.1 |
| Seldom | 78 | 26.3 | 76 | 38.5 |
| Often | 109 | 36.8 | 106 | 53.8 |
| Frequently | 63 | 21.3 | 3 | 1.5 |
| Regularly | 45 | 15.2 | 1 | 0.5 |
| Total | 296 | 99.9 | 197 | 100.0 |

[a] Among 38 control households for consumption of raw fish, information was not available.

[b] For cooked fish, not malansa, 14 control households and 16 leper households had no data.

separately or both at the same time, at the table every day or almost daily. Doubtless, there is a considerable amount of indiscriminate eating of both fruits and sweets between meals, especially among the children.

TABLE 31.—*Consumption of pork, beef and chicken, and milk in the two groups of households.*

| Frequency at table. | Pork. | | | | Beef and chicken. | | | |
|---|---|---|---|---|---|---|---|---|
| | Control households. | | Leper households. | | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| Never | 2 | 0.6 | 5 | 2.4 | 8 | 2.5 | 1 | 0.3 |
| Very seldom | 97 | 31.3 | 37 | 17.4 | 115 | 37.1 | 50 | 23.6 |
| Seldom | 109 | 35.2 | 113 | 53.0 | 116 | 37.4 | 130 | 61.0 |
| Often | 91 | 29.4 | 41 | 19.2 | 68 | 22.0 | 30 | 14.1 |
| Frequently | 6 | 1.9 | 7 | 3.3 | 2 | 0.6 | 0 | 0.0 |
| Regularly | 5 | 1.6 | 10 | 4.7 | 1 | 0.3 | 2 | 0.9 |
| Total | 310 | 100.0 | 213 | 100.0 | 310 | 99.9 | 213 | 99.9 |

| Frequency at table. | Milk. | | | |
|---|---|---|---|---|
| | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* |
| Never | 171 | 55.0 | 109 | 51.2 |
| Very seldom | 51 | 16.5 | 28 | 13.2 |
| Seldom | 56 | 18.1 | 55 | 25.8 |
| Often | 21 | 6.8 | 17 | 8.0 |
| Frequently | 6 | 1.9 | 3 | 1.4 |
| Regularly | 5 | 1.6 | 1 | 0.3 |
| Total | 310 | 99.9 | 213 | 99.9 |

TABLE 32.—*Consumption of fruits and sweets with the meals.*

| Frequency at table.[a] | Households. | | | |
|---|---|---|---|---|
| | Control. | | Leper. | |
| | | *P. ct.* | | *P. ct.* |
| Never | 159 | 58.0 | 84 | 40.6 |
| Very seldom | 42 | 15.3 | 41 | 19.8 |
| Seldom | 55 | 20.1 | 70 | 33.8 |
| Often | 15 | 5.5 | 11 | 5.3 |
| Frequently | 1 | 0.4 | 1 | 0.5 |
| Regularly | 2 | 0.7 | 0 | 0.0 |
| Total | 274 | 100.0 | 207 | 100.0 |

[a] No data on 36 control and 6 leper households.

TABLE 33.—*Ownership of carabaos, horses, and pigs in control and leper households.*[a]

| Number of animals. | Carabaos. | | | | Horses. | | | |
|---|---|---|---|---|---|---|---|---|
| | Control households. | | Leper households. | | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 1 to 3 | 28 | 10.7 | 22 | 11.1 | 4 | 1.5 | 13 | 6.5 |
| 4+ | 1 | 0.4 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| No animal | 233 | 89.0 | 177 | 88.9 | 258 | 98.5 | 185 | 93.0 |
| Total | 262 | 100.1 | 199 | 100.0 | 262 | 100.0 | 199 | 100.0 |

| Number of animals. | Pigs. | | | |
|---|---|---|---|---|
| | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* |
| 1 to 3 | 165 | 63.0 | 121 | 60.8 |
| 4+ | 20 | 7.6 | 15 | 7.5 |
| No animal | 77 | 29.4 | 63 | 31.7 |
| Total | 262 | 100.0 | 199 | 100.0 |

[a] In the three tables showing ownership of animals, no information is available in 48 control and 14 leper households.

TABLE 34.—*Ownership of goats and cows among control and leper households.*

| Number of animals. | Goats. | | | | Cows. | | | |
|---|---|---|---|---|---|---|---|---|
| | Control households. | | Leper households. | | Control households. | | Leper households. | |
| | | *P. ct.* | | *P. ct.* | | *P. ct.* | | *P. ct.* |
| 1 to 3 | 19 | 7.3 | 17 | 8.5 | 5 | 1.9 | 9 | 4.5 |
| 4+ | 3 | 1.1 | 4 | 2.0 | 0 | 0.0 | 0 | 0.0 |
| No animal | 240 | 91.5 | 178 | 89.5 | 257 | 98.1 | 190 | 95.5 |
| Total | 262 | 99.9 | 199 | 100.0 | 262 | 100.0 | 199 | 100.0 |

TABLE 35.—*Varieties of animals owned.*

| Number of varieties. | Households. | | | |
|---|---|---|---|---|
| | Control. | | Leper. | |
| | | *P. ct.* | | *P. ct.* |
| No animal | 65 | 24.8 | 49 | 24.6 |
| One kind only | 161 | 61.4 | 107 | 53.7 |
| Two kinds | 31 | 11.8 | 34 | 17.1 |
| Three or more kinds | 5 | 1.9 | 9 | 4.5 |
| Total | 262 | 99.9 | 199 | 99.9 |

Summarizing the information obtained by the simple method that has been employed in the present report, we may say that the main differences in the diet of the control and the leper households seemed to lie in the fact that the latter tended to eat more of the more expensive rice in addition to their staple grain of corn, at the sacrifice of their vegetables and fish, especially fresh fish. The consumption of meat and meat products was about the same in the two groups. There was also noted an undoubted more-marked predisposition to the eating of raw shellfish as well as uncooked fish among the households where leprosy has appeared than among households living in the same localities and of about the same economical status, which have been respected by the disease.

### OWNERSHIP OF DOMESTIC ANIMALS OF ECONOMIC VALUE

The families under study, being poor, had very few work animals. This is shown in Tables 33, 34, and 35. About 11 per cent in both control and leper groups had carabaos. The proportion of households owning horses, pigs, goats, and cows is likewise about the same in both groups. Table 33 shows that the pig is the commonest domestic animal; only about 30 per cent of both sets of households have no pigs.

Table 35 requires a brief explanation to clarify its meaning. In this table, the households are classified according to the number of varieties of domestic animals of economic value owned by each household. In other words, the figures indicate the number of kinds of animals, rather than the number of animals. When the control and the leper households are compared on this basis, no significant difference is noted.

## ANALYSIS OF DATA ON THE ACTUAL CASES OF LEPROSY AND THEIR CONTACTS

### POSITIVE LEPERS

There had developed in the "positive leper" households surveyed, a total of 126 cases of leprosy, of whom 82 were males and 44 were females; 15 males and 19 females (total, 34 cases) were found in Cebu, while the rest (67 males, 25 females, total, 92 cases) occurred in Opon, Mactan Island.

Tables 36, 37, and 38 give data regarding the age and sex distribution, occupation, and literacy among these positive cases. The totals appearing in these tables are not the same in the three tables because whenever data regarding the subject of the table were lacking, the cases were not included in the tabulation.

For instance, as regards age and sex distribution, complete data were available only in 117 of the total of 126 lepers; in 9 cases (4 males and 5 females) the data as to age were lacking so these do not appear in Table 36. This table shows that 55, or 47.0 per cent, of the 117 cases were under 20 years of age at the time the diagnosis was made. There were 7 children under 10 years.

TABLE 36.—*Age and sex distribution of cases of leprosy and suspects.*

| Age. | Incipients. | | | Positives. | | | Paroled. | | | Suspects. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. | M | F | Total. | M | F | Total. |
| *Yrs.* | | | | | | | | | | | | |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 to 9 | 5 | 6 | 11 | 4 | 3 | 7 | 0 | 0 | 0 | 1 | 1 | 2 |
| 10 to 14 | 12 | 9 | 21 | 11 | 11 | 22 | 1 | 1 | 2 | 0 | 3 | 3 |
| 15 to 19 | 14 | 16 | 30 | 18 | 8 | 26 | 4 | 2 | 6 | 3 | 0 | 3 |
| 20 to 29 | 21 | 13 | 34 | 28 | 14 | 42 | 9 | 2 | 11 | 0 | 1 | 1 |
| 30 to 39 | 3 | 3 | 6 | 10 | 1 | 11 | 6 | 2 | 8 | 0 | 0 | 0 |
| 40 to 49 | 2 | 2 | 4 | 1 | 1 | 2 | 4 | 2 | 6 | 0 | 0 | 0 |
| 50 to 59 | 0 | 3 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 to 69 | 0 | 0 | 0 | 5 | 0 | 5 | 1 | 0 | 1 | 0 | 0 | 0 |
| 70 to 79 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| 80 to 89 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| No data | 0 | 0 | 0 | 4 | 5 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 57 | 52 | 109 | 82 | 44 | 126 | 25 | 10 | 35 | 4 | 5 | 9 |

TABLE 37.—*Occupations of cases of leprosy.*

| Occupation. | Incipients. | | | Positives. | | | Paroled. | | | Suspects. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. | M | F | Total. | M | F | Total. |
| Domestic | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Employee | 5 | 0 | 5 | 2 | 0 | 2 | 1 | 0 | 1 | 0 | 0 | 0 |
| Farmer | 7 | 1 | 8 | 6 | 0 | 6 | 3 | 0 | 3 | 0 | 0 | 0 |
| Fisherman | 0 | 0 | 0 | 6 | 0 | 6 | 2 | 0 | 2 | 0 | 0 | 0 |
| Merchant | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ordinary laborer | 7 | 2 | 9 | 15 | 3 | 18 | 11 | 0 | 11 | 0 | 0 | 0 |
| Skilled laborer | 8 | 3 | 11 | 2 | 3 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Professional | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Property owner | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| Student | 14 | 11 | 25 | 12 | 12 | 24 | 1 | 0 | 1 | 0 | 4 | 4 |
| Housework | 0 | 25 | 25 | 0 | 7 | 7 | 0 | 8 | 8 | 0 | 0 | 0 |
| No occupation | 10 | 0 | 10 | 9 | 4 | 13 | 6 | 2 | 8 | 3 | 1 | 4 |
| Total | 52 | 44 | 96 | 52 | 30 | 82 | 25 | 10 | 35 | 3 | 5 | 8 |

TABLE 38.—*Literacy among cases of leprosy.*

| Language. | Incipients. | | | Positives. | | | Paroled. | | | Suspects. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | Total. | M | F | Total. | M | F | Total. | M | F | Total. |
| English and Spanish | 0 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| English | 37 | 25 | 62 | 22 | 13 | 35 | 7 | 0 | 7 | 0 | 1 | 1 |
| Spanish | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Visayan | 4 | 2 | 6 | 8 | 3 | 11 | 6 | 2 | 8 | 1 | 0 | 1 |
| Illiterate | 11 | 13 | 24 | 20 | 11 | 31 | 12 | 8 | 20 | 3 | 3 | 6 |
| Total | 52 | 40 | 92 | 51 | 29 | 80 | 25 | 10 | 35 | 4 | 4 | 8 |

As to occupation, Table 37 indicates that of 82 individuals above 10 years old about which this item was known, 6, or 7.3 per cent, were fishermen; 6, or 7.3 per cent, were farmers; only 5, or 6 per cent, were skilled laborers; 18, or 21.8 per cent, were ordinary laborers; 24, or 29.2 per cent, were students; and 13, or 15.8 per cent, had no occupation.

The history of contact with a previous case was carefully investigated in every case of leprosy. In 16 cases, the information obtained was considered doubtful and they were excluded from the following discussion. Among the remaining 110 cases, 88, or 80 per cent, gave a definite history of contact with a leper previous to the onset of the disease. In 48, or 43.63 per cent, the leper source of the infection lived in the same household; in 23, or 20.9 per cent, the source was a relative who lived outside the household; while in 17, or 15.5 per cent, the source was a nonrelative who lived outside the household. In the last class the leper source was usually a neighbor or a playmate.

It has already been stated that only 34 positive lepers from Cebu city were included in the survey. It will also be recalled that there were 32 "positive leper" families visited. There were only two families in which more than one case appeared in the household.

On the other hand, there were 56 "leper" homes on Mactan Island surveyed and among them, there were 92 positive lepers found. Calling the first case recorded in a household the "primary" case and the subsequent ones "secondary" cases for lack of better terms, there were therefore 56 primary and 36 secondary cases. It must not be inferred from the use of these terms that the latter were necessarily derived from the former, since both may have been infected from the same source, and in the primary cases the disease simply manifested itself earlier.

At any rate, there were 44 male and 12 female "primary" cases, while 23 males and 13 females composed the "secondary" cases. As a rule, the secondary cases were somewhat younger at the time of segregation than the first cases.

It would seem from the above discussion that there exists a difference between the urban and the rural groups in that there are more multiple cases occurring among the latter. This difference is probably more apparent than real on account of the following circumstances:

1. The "positive" households surveyed in the city were visited sooner after detection of the leper and the cases as a group were more recent than the ones studied at Opon.

2. A list of all lepers whose names appear in the records as having been segregated from Opon since 1904, was prepared in 1929 and many of their homes had been located previous to the present survey. Although only recent ones are included in the present investigation, we had more definite information about the previous cases in Opon than in Cebu. In many instances, the head of the family at Opon either did not mention or actually denied the existence of previous cases in the family until the records were shown to him. It has not been possible to prepare a similar list for Cebu, and it is possible that many of the lepers reported there as "primary" will turn out to be "secondary" cases later on.

3. The population at Opon was more stable. In the city, there is apt to be more shifting about of the population.

4. The rural people were much more coöperative, and the inhabitants of Opon were better informed about the affairs of their neighbors than those in the city.

Of 1,370 persons exposed to 213 (primary) cases of leprosy (incipients, positives, and paroled combined), 57 developed the disease subsequently, which gives a rate of 4.16 per cent. It must be remembered that the subsequent cases did not necessarily develop from the first recorded case in the household.

Of 617 persons exposed to 88 positive cases, 38 developed leprosy, which is an incidence of 6.14 per cent.

The duration of the exposure has not been taken into account in the above discussions. This matter will be taken up in a subsequent report. In order to facilitate further analyses of these cases definitely diagnosed as leprosy, a graph for each household, indicating the age of each person in the household including the lepers, is being prepared. The lepers are represented by red lines and the nonleper contacts by blue lines.

By means of symbols, it is possible to show in the same chart the progress of the disease among those becoming leprous. Thus, at a glance, an idea may be had of the age and sex constitution of the contacts to a particular case, as well as the duration, course, etc., of the disease in the leper. By means of this graph, it will be possible in later years to correlate the frequency of secondary cases to the duration of exposure, the average age of the contacts during this period, and the time that had elapsed since the leper was segregated. It should be possible in selected cases also to correlate incidence of secondary cases to type of lesion found in the leper.

The results should prove interesting in view of the fact that we are at present observing a number of "closed" cases and even "paroled ex-lepers" in newly established families.

### INCIPIENT LEPERS

Coming now to the incipient or "closed" cases, there were 109 in all, from both districts, 57 being males and 52 females. The data regarding them also appear in Tables 36, 37, and 38.

There were 91 families with incipient lepers, so that there were 18 "secondary" cases.

In age distribution, 62, or 56.8 per cent, were under 20 years old. As was to be expected, they were, as a group, younger than the "positive" cases among whom 47 per cent were of corresponding age.

As regards occupation, there were no fishermen among them; 8, or 8.3 per cent, were farmers; 11, or 11.4 per cent, were skilled laborers; 9, or 9.3 per cent, were ordinary laborers; 25, or 26 per cent, were students; 10, or 10.4 per cent, of those above 10 years had no occupation, while 11 were children under 10 years of age.

It is interesting to observe that the relative number of fishermen among the lepers is less than among the control population.

There were relatively more skilled laborers among the unaffected individuals than among the positive cases and about the same proportion of students. There were fewer jobless among the former, too. It should be borne in mind that these were "closed" cases and some of them may never progress to the "positive" stage.

As to literacy, it was possible to gather data only in 92 cases above 10 years of age, of whom 24, or 26.1 per cent, were illiterates. This record compares favorably with that of 38.7 per

cent illiteracy among the positive lepers and 38.5 per cent in the control population.

In attempting to obtain the history of previous contact with a definite bacteriologically positive case of leprosy among these incipient cases, we failed to obtain reliable data in 38 instances. Among the remaining 71, 48, or 67.6 per cent, gave a history of definite contact with an undoubted "positive" leper; in only 9, or 2.7 per cent, was the leper in the household. Twenty-nine had been in contact with leper relatives outside the household and 10 gave a history of contact with a nonrelative leper also outside the household.

There was noted a much higher percentage of household infection among the positive or open cases of leprosy than among the "closed" or "incipient" cases.

### PAROLED EX-LEPERS

There were 35 paroled ex-lepers in 34 homes. In 8, or 22.6 per cent, the age was below 20 years, indicating that they were older than the "positive" and "incipient" lepers. Eleven, or 31.4 per cent, were ordinary laborers and 8, or 22.6 per cent, had no jobs.

### SUSPECTS

Nine cases were found to have lesions suspected of leprosy by the field workers, but due to lack of money for transportation they could not report to the dispensary for confirmation of the diagnosis. Eight were previously associated with positive lepers, while one was living with an incipient case.

### SUMMARY

In December, 1932, the writers started to gather epidemiologic data on the recently discovered cases of leprosy found in the city of Cebu and its environs. The main focus of leprosy in the province had been found to be located in a roughly circular area with a radius of about 20 kilometers and with the capital at its center. Cases coming from more distant areas could not be studied due to lack of funds. However, an effort was made to study as many cases as possible of those discovered in the town of Opon, on Mactan Island, across the narrow strait from the city of Cebu, in order to include cases from a rural district in the study. The individual histories of the patients were investigated, and the economic, hygienic, and social conditions of the households in which they had been living since the probable

onset of the disease, were also studied. In this manner, it was hoped that some idea might be had of the conditions that favor the development of leprosy. It was obviously important to have controls, consisting of normal persons and households living in the same area as the lepers and the households that have been affected by leprosy.

It was decided to survey particularly the entire barrio of Baud in the San Nicolas district of the city of Cebu, as well as 5 barrios of the municipality of Opon, on Mactan Island, all of which were known to be heavily infected with leprosy. We had planned to examine every person in these barrios for signs of leprosy, and to survey all the households in them, including of course those in which the disease had developed. However, due to the reduction of personnel, following the reorganization of the Government in March, 1933, the investigation could not be continued as intensively and extensively as originally planned. After continuing for two more months, it was decided to analyze the data then available, in order to be able to replan the investigation on the basis of the reduced personnel with more adequate knowledge of actual conditions.

Up to the end of May, 1933, 95 control (498 persons) and 98 "leper" households (649 individuals) had been surveyed in the city of Cebu. By "leper" households or families are meant those households in which one or more cases of leprosy were definitely known to have developed. The individuals in such households may therefore be considered "contacts" to the disease, except those who were born after the leper had been segregated. The control households consisted of those which, in spite of the fact that they were living in an endemic area of leprosy with the "leper" households, have not been known to have been affected with the disease. These families constitute the "urban" group studied.

In the municipality of Opon, 330 "rural" households, representing 1,983 persons of both sexes and all ages, were visited. Of these households, 215 were control and 115 were "leper" families. In all, there have been surveyed, therefore, 310 control (1,817 persons) and 213 "leper" households (1,313 persons) or a total of 523 families, representing 3,130 persons. This is only about one-third of the total population of Baud and of the 5 barrios of Opon that we desire to survey.

Due to the fact that the entire population of these barrios has not been examined, it has not been possible in the present

report to determine the incidence of leprosy or its rate as to sex, by age groups, by occupations, by incomes, as to literacy, etc. Naturally, this has proven an unsurmountable handicap in the analysis of our data, and we have been forced to use less dependable methods of analysis. However, we consider the results of sufficient interest to merit publication.

Moreover, towards the middle of July, 1933, a similar epidemiologic survey was started in the municipality of Cordova, which also lies on Mactan Island, under the auspices of the Leonard Wood Memorial, by Dr. James A. Doull, with the cooperation of the personnel of the Bureau of Health. With the ample resources available for this special survey and the matured experience of Doctor Doull as an epidemiologist, there can be no doubt that the entire population of Cordova will be examined and accurate data regarding the households will be secured. It will then be possible to determine the incidence of the disease as well as to work out rates as to age, occupation, etc. The result of this survey will doubtless be an important contribution to the epidemiology of leprosy.

In the first section of the present report, the total population of the normal and the "leper" groups of households are compared as to age and sex distribution, occupation, literacy, and mortality.

In the following section, the two sets of households are compared as to type of houses, overcrowding, amount and kind of vegetation about the houses, sanitary condition, size of family, family income, diet, and ownership of domestic animals.

Finally, the last section takes up the analysis of the data regarding the lepers themselves with regard to age and sex distribution, occupation, and literacy.

## CONCLUSIONS

1. Comparing the total population of the households where leprosy had developed with that of the control households as to age and sex, it was found that the mean ages of both sexes were higher in the former group than in the latter; no significant difference in the proportion of males to females was noted. There was more illiteracy among those living in leper households and the death rate was higher, although the latter was not statistically significant. There was no important difference as to occupation.

2. Comparing the control and "leper" households as to type of house and overcrowding, we have found that the latter as a

rule were housed in better homes which were not as crowded together as the controls, but that there was more overcrowding within the houses themselves.

3. With regard to amount of vegetation about the house, the "leper" houses had less vegetation about them than the controls.

4. As to sanitary conditions, the "leper" households were using, on the average, drinking water of better sanitary quality and also had safer means of sewage disposal, but were dirtier both as to surroundings and with regard to their persons than the controls. They had less cleanly habits as indicated by the more frequent presence of large and ill-smelling "pusali" under their houses and less frequency of bathing among them.

5. The leper families were larger than the controls.

6. The family income was about the same in the control and the leper households. Both groups, however, belong to the poorer or possibly the poorest classes in Cebu Province. When the population of the province is taken as a whole, the disease will be found to attack chiefly the poorest households.

7. The main differences in the diet of the control and the leper households consisted of the fact that the latter tended to eat more rice which is more expensive than corn, the local staple grain, at the expense of their vegetables and fish, specially fresh fish.

The consumption of meat and meat products was about the same in the two groups. However, these food items, except pork, seldom appear on the poor man's table in Cebu.

The "leper" households tended to eat more raw shellfish as well as uncooked fish than the controls.

8. Forty-seven per cent of the "positive" lepers were under 20 years of age when the diagnosis of leprosy was made. Among the "closed" or "incipient" cases, 57 per cent were of corresponding age at the time of diagnosis.

9. Leprosy was not associated with any particular occupation in the areas studied.

10. The proportion of illiterates among the lepers was not different from that in the general population of corresponding age and sex.

11. It was possible to obtain an authenticated history of contact with a previous case of leprosy in 80 per cent of the "positive" lepers; in 44 per cent, the source of infection had lived in the same household. Among the "closed" cases, however, the source could be traced only in 68 per cent of the cases and only in 3 per cent had the leper source lived in the same house.

# EXPERIMENTS ON THE CONTROL OF THE COMMON WATER LEECH, HIRUDINARIA MANILLENSIS [1]

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TWO PLATES

## INTRODUCTION

The common water leech, or carabao leech, *Hirudinaria manillensis* (Lesson) ( = *Hirudo boyntoni* Wharton, 1913) and in the vernacular *lintá* or *lintang kalabao,* is abundant enough in the Philippines to be of considerable economic importance. This species of medicinal leech, according to Harding and Moore (1917), occurs also in Java, Ceylon, Siam, and southern India. It is found in great numbers in ponds, pools, brooks, and irrigation ditches that are frequented by carabaos and in rice paddies that contain water throughout or during the greater part of the year.

The carabao leech is an injurious and dangerous annelid. It attacks not only carabaos that wallow in its habitat but also cattle which drink there. Human beings who work in rice paddies or fish in leech-infested places are subject to attack. People and carabaos suffer considerably from its bite. Owing to its notoriously sanguivorous habit and to its size, one mature *H. manillensis* can suck about 10 to 20 cubic centimeters of blood so that a great number of mature leeches attacking a carabao at the same time will draw a large amount of blood. It is not uncommon to see a carabao with several engorged leeches dangling from its sides and belly when it leaves a wallow. Sometimes one or more leeches stick to the muzzle or invade the nostrils of a carabao; the resulting annoyance and pain cause the animal to run aimlessly, snort violently, and rub its nose and mouth against plants or the ground. Cattle are annoyed in the same way when they drink in leech-infested

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places and possibly horses may be also. Experimentally and in nature, the carabao seems not to notice the leeches biting and sticking to its skin except when on the muzzle or around the anus. Leech bites are dreaded by most people who work in infested rice paddies, because, besides the tickling sensation and itching at the points of the bites, the victim may lose much blood and the points of bites may act as portals of entry of certain pathogenic bacteria. Harding and Moore (1927) point out that the habit of sanguivorous leeches of congregating about inflamed sores or wounds and abrasions that may be already infected, together with their proneness to pass from host to host, make them almost perfect simple mechanical carriers of bacterial infections.

*Hirudinaria manillensis* acts as a host reservoir of certain pathogenic microörganisms. Boynton (1913) reports that this leech can retain the virus of rinderpest alive in its body for at least twenty-five days and in a virulent condition. This investigator points out that as this leech cannot transmit the rinderpest virus through bites alone it transmits the virus to healthy animals by disgorging part of the virulent blood either on the grass or into the water. Sakharov, Rosenbach, Blumer, Hamburger, and Mitchell (cited by Bass and Johns, 1912) kept malarial plasmodia alive for several days in medicinal leeches that had been allowed to draw the blood of malarial patients. However, *H. manillensis* cannot act as a host reservoir or mechanical transmitter of the trypanosome of surra. According to Boynton (1913), the trypanosome of surra does not remain alive for any length of time in the ingested blood of *H. manillensis* and this leech cannot transmit the disease by biting. Miyao (1932) reports that the possibility of transmission of yaws by the common water leeches in the Philippines is very remote. Tubangui (1932) states that by means of interrupted-feeding experiments it was determined that this water leech is unable to transmit surra either directly or indirectly.

Blood-letting by means of medicinal leeches is a practice of the past. In the nineteenth century, according to Shipley (1927), the artificial cultivation of leeches was a profitable industry in Europe as they were in great demand in European hospitals. Nachtrieb (1912) states that in those days one American leech farm sold as many as one thousand or more leeches a day. While medicinal leeches are still sold at some drug stores even in Manila, the medical profession condemns the employment of these annelids in phlebotomy. The practice,

however, is still carried on in the Philippines by the *mediquillos* or quacks, but the medicinal leech, like *Hirudinaria manillensis*, has outlived its usefulness and has become but an injurious pest which deserves extermination.

The object of the study here reported was to find some practical methods of controlling or possibly exterminating, at least in certain places, the common water leech.

## MATERIALS AND METHODS

With the help of Drs. R. Q. Javier, N. S. Sevilla, M. C. Villanueva, and several students of the College of Veterinary Science, many specimens of the common water leech, *Hirudinaria manillensis*, were collected from rice paddies, brooks, and pools in Lumbang, Laguna, and in Tupas, Nueva Vizcaya, in 1930; in Papaya, Nueva Ecija, in 1931; in Pila, Santa Rosa, and Bay, Laguna, and in San Narciso, Zambales, in 1932. The leeches were kept in large bottles and jars half-filled with water, which was changed every two or three days.

Only cheap and easily available materials were used in the different killing experiments. Solutions of copper sulphate of commercial quality were prepared, varying in proportion from 1: 1,000 to 1: 1,000,000. Crude common salt (sodium chloride), prepared in the Philippines by evaporating sea water in the open during the dry season, was used in one experiment in 1 to 5 per cent solutions. Solutions of commercial chemical fertilizers, such as, ammonium sulphate, superphosphate, potassium sulphate, calcium nitrate, potassium chloride, Leunaphos IG, Corona Special, ammonium phosphate, and Double Crop No. 1, were tested for their killing power on the water leech. In eighteen flasks 1 and 2 per cent solutions were prepared in 400-cc quantities.

Infusions of certain parts of plants that are known or said to be poisonous to fish and are easily obtainable in the Islands were prepared and used in three experiments. Fresh tubers of *namí* (*Dioscorea hispida* Dennst.) were chopped into small thin chips, and infusions were made varying in proportion from 1: 100 to 1: 1,000. The fresh roots of *tuble* (Vis.) or *tibanglan* (Tag.) [*Derris elliptica* (Roxb.) Benth.] were chopped into small chips, and after drying in the room for five days, were coarsely ground in a small grinding machine. Infusions, varying in proportion from 1: 100 to 1: 1,000, were prepared from these ground roots. Both the namí and this species of *Derris*

grow wild and in abundance in thickets and margins of forests in the Philippines. Dried tobacco (Isabela variety) midribs were cut into pieces about 2 inches long and infusions of these, varying in proportion from 1: 100 to 1: 1,000, were used in one experiment. Truck loads of tobacco midribs are burned in the Manila Crematory almost every day.

In all cases, the solutions and infusions were placed in 500-cc Erlenmeyer flasks and in 2,000-cc, tall, cylindrical museum jars. These were covered with two layers of strong bobbinet. Four leeches of different sizes, two large and two small, were used in each trial in the different killing experiments. Observations were made every hour when the leeches were exposed to strong solutions and infusions and every three to six hours when exposed to weaker ones.

The commonest fishes in the rice paddies are the murrel, or *dalag* (*Ophicephalus striatus* Bloch); the catfish, or *hitó* [*Clarias batrachus* (Bloch)], and the climbing perch, or *tinikan* [*Anabas testudineus* (Bloch)]. Several of these fishes were caught in rice paddies and in Laguna de Bay and kept in a laboratory aquarium or in an experimental pool.

The experimental pool (Plate 2, fig. 2) was made by digging an extensive pit, 3.7 meters long, 2.6 meters wide, and 0.6 meter deep. Water was constantly supplied the pool from a faucet, which was kept running at a force that kept the depth of the water between 0.3 and 0.45 meter. The pool was provided with a 4-inch drain pipe, the proximal end of which was covered with a piece of fine wire netting to prevent the leeches from escaping with the outflowing water. The water in this pool could be siphoned off by means of a long rubber hose. To prevent the leeches from escaping with the water through the hose, the proximal end of the tube was covered with two layers of gauze. To make it a balanced aquarium and like a rice paddy or a natural pool, rice of lowland variety, taro or *gabi*, and *cangcong* [*Ipomoea reptans* (Linn.) Poir.] were planted in the corners and center. Fifty-two snails of different sizes, collected from Molawin Creek, were let loose in the pool.

The domesticated ducks used in the hand-feeding and natural-feeding experiments are zoölogically known as *Anas boschas* Linn. and vernacularly known as *itek* or *bebe* (Plate 2, fig. 1). This species of duck is extensively raised along the shores of Laguna de Bay and along the banks of Pasig River, as well as on the banks of ponds and rivers in other parts of the Philippines.

For convenience, the leeches were divided arbitrarily into two groups; namely, young leeches (Plate 1, fig. 2), which measured from 3.71 to 6.25 cm long, and mature leeches (Plate 1, fig. 1), which measured from 7.62 to 11.43 cm long.

## EXPERIMENTS AND RESULTS

### TO DETERMINE THE RELATIVE KILLING POWER ON HIRUDINARIA MANILLENSIS OF SOLUTIONS OF COPPER SULPHATE

*Experiment 1.*—The solutions of copper sulphate (commercial) in 500-cc quantities were placed in three flasks and three jars. Four leeches of different sizes—that is, two young ones and two mature ones—were put in each solution. The leeches were examined every hour, every six hours, or every day for one week, depending upon the strength of the solution. To determine whether or not the leeches were living, they were touched with one end of a stirring rod; and, in case of doubt, they were removed from the solution and were placed in tap water in a large beaker and observed for vitality. This experiment was repeated and the same procedure was followed. The results, which were the average of those obtained from two trials are shown in Table 1.

TABLE 1.—*Showing the relative killing power on Hirudinaria manillensis of various solutions of copper sulphate.*

| Solution. | Results of exposure of— | |
|---|---|---|
| | Young leeches. | Mature leeches. |
| 1:1,000 | Died in 1 hour | Died in 2 to 2.5 hours. |
| 1:10,000 | Died in 2 to 3 hours | Died in 5 to 7 hours. |
| 1:50,000 | Died in 18 to 24 hours | Died in 48 to 75 hours. |
| 1:100,000 | Died in 48 to 57 hours | Not affected. |
| 1:500,000 | Died in 10 days | Do. |
| 1:1,000,000 | Not affected | Do. |

### TO DETERMINE THE RELATIVE KILLING POWER ON THE CARABAO LEECH OF SOLUTIONS OF CRUDE COMMON SALT

*Experiment 2.*—Solutions of crude common salt were prepared in five flasks, in 300-cc quantities. As in experiment 1 four leeches of different sizes were placed in each solution. The leeches in the higher solutions were examined for their behavior and vitality every two or five minutes, and those in 1 and 2 per cent solutions, every six hours. This experiment was repeated; the average of the results from two trials are shown in Table 2.

TABLE 2.—*Showing the relative killing power on H. manillensis of solutions of crude common salt.*

| Solution. | Results of exposure of— | |
|---|---|---|
| | Young leeches. | Mature leeches. |
| *Per cent.* | | |
| 1 | Not affected | Not affected. |
| 2 | Died in 12 to 24 hours | Died in 48 to 75 hours. |
| 3 | Died in 22 minutes to 2.5 hours | Died in 3 to 7 hours. |
| 4 | Died in 17 to 25 minutes | Died in 1 to 2 hours. |
| 5 | Died in 10 to 15 minutes | Died in 30 to 70 minutes. |

DETERMINATION AS TO WHETHER OR NOT SOLUTIONS OF COMMERCIAL CHEMICAL FERTILIZERS WILL KILL THE CARABAO LEECH

*Experiment 3.*—Four leeches of different sizes, as in experiment 1, were put in each solution. Observation for vitality was made every six or twelve hours. All the leeches in the 1 and 2 per cent solutions remained alive even after a continuous exposure of one month.

DETERMINATION AS TO WHETHER OR NOT INFUSIONS OF NAMÍ WILL KILL THE CARABAO LEECH

*Experiment 4.*—Infusions of namí tubers in 500-cc quantities were placed in five museum jars, and four leeches were placed in each of the jars. After an exposure of one week it was found that even the 1: 100 infusion did not affect the leech at all.

TO DETERMINE THE KILLING POWER ON THE CARABAO LEECH OF INFUSIONS OF TOBACCO MIDRIBS

*Experiment 5.*—The same technic as in experiment 4 was followed. Observations were made every five minutes in case of the stronger infusions and every one or six hours in case of the weaker ones. This procedure was repeated under similar conditions. The averages of the results are shown in Table 3.

TABLE 3.—*Showing the relative killing power on H. manillensis of the infusions of tobacco midribs.*

| Infusion. | Results of exposure of— | |
|---|---|---|
| | Young leeches. | Mature leeches. |
| 1:100 | Died in 15 to 17 minutes | Died in 37 to 42 minutes. |
| 1:200 | Died in 1 hour to 3 hours 22 minutes | Died in 11.5 to 24 hours. |
| 1:400 | Died in 12 to 24 hours | Died in 28 to 72 hours. |
| 1:600 | Died in 5 days | Died in 7 days. |
| 1:800 | Not affected | Not affected. |
| 1:1,000 | do | Do. |

TO DETERMINE THE RELATIVE KILLING POWER ON THE CARABAO LEECH OF INFUSIONS OF DERRIS ELLIPTICA ROOTS

*Experiment 6.*—The same technic as in experiment 4 was followed, except that the derris roots were coarsely ground before being used. This experiment was also repeated under similar conditions; the averages of the results are shown in Table 4.

TABLE 4.—*Showing the relative killing power on H. manillensis of infusions of Derris elliptica.*

| Infusion. | Results of exposure of— | |
|---|---|---|
| | Young leeches. | Mature leeches. |
| 1:100 | Died in 1 to 2.5 hours | Died in 6.5 to 17 hours. |
| 1:200 | Died in 3 to 3.5 hours | Died in 10 to 21 hours. |
| 1:500 | Died in 7 to 13 hours | Died in 21 to 33 hours. |
| 1:700 | Died in 14 to 29 hours | Died in 65 to 72 hours. |
| 1:1,000 | Died in 24 to 48 hours | Died in 54 to 75 hours. |

DETERMINATION AS TO WHETHER OR NOT TEMPORARY DRAINING OR DRYING AN INFESTED PLACE WILL KILL THE CARABAO LEECH

*Experiment 7.*—Three empty kerosene cans were thoroughly cleaned to remove traces of kerosene. About fifty holes, 3 mm in diameter, were punched in the bottom of each can for drainage. The cans were filled with a mixture of one part of fresh carabao manure and fifty parts of loose soil. With a liberal amount of water and by thoroughly stirring this mixture was given the consistency of rice-paddy mud.

August 23, 1932. Three leeches, varying in length from 6.25 to 11.43 cm, were allowed to bury themselves in each of the three mud preparations. The leeches readily wiggled their way into the mud. Every sunny day, these leech cultures were placed in the sun from 7 o'clock in the morning to 5.30 in the afternoon; but on rainy days and every night, they were kept under the eaves of a house. Every night the cans were covered tightly with fine wire netting to prevent the leeches from escaping.

September 23, 1932. One month later, one leech culture was examined for living leeches. The upper part of the mud was dry and hard and was traversed by large deep cracks. No leech could be seen in the cracks. When the surface of the mud was liberally covered with water, a large vigorous leech appeared in the water ten minutes later. A thorough examination of the mud revealed that the leeches probably remained in the lower

layer of the drying mud where they bored tunnels communicating with the cracks in the upper layer. The walls of the lower end of one tunnel were found covered with a thin layer of thick mucoid substance. No traces, however, of the other two leeches could be found.

October 23, 1932. Two months later, a second leech culture was examined for living leeches. Three tunnels were found in the dried mud, but neither living leeches nor traces of their bodies could be found. It is highly probable that the leeches in this culture escaped, because on October 10, 1932, a large fully engorged leech was found in a small shallow mud hole just 3.5 meters from the leech cultures. No leech had ever been found in this place before, and, being well drained, it was not likely that leeches could breed in this place. This particular place was frequented every night by five experimental carabaos so the leeches in the culture must have been attracted by their odor and escaped from the culture. On testing the efficiency of the wire-netting cover of this can, it was found that a leech could easily escape by passing between the lip of the can and the wire netting.

November 23, 1932. Three months later, the last leech culture was examined for living leeches. Thirty minutes after the dried mud was flooded, no leech had appeared in the water. The dried mud was then broken into small pieces and particular care was taken to look for tunnels made by the leeches. In the lower ends of two tunnels two living leeches were found covered with thick mucoid substance, and when they were placed in water, they showed their usual vigor.

*Experiment 8.*—September 5, 1932. Four leeches, two mature and two young ones, were placed in a cylindrical museum jar, 14 inches high and 4 inches in diameter, in which there was a mixture of one part of fresh carabao manure and fifty parts of mud. The jar was tightly covered with a double layer of bobbinet and was placed on a table near a window where every afternoon it was exposed to the sun for about three hours. The leeches could be observed moving in their tunnels close to the wall and near the bottom of the jar.

November 3, 1932. Examination of this leech culture was made by emptying the contents of the jar on a cement floor where the mud was broken into small pieces. Three living, vigorous leeches, one young and two mature ones, were found at the bottom of the jar. The whole contents, including the leeches, were returned to the jar for further observation.

December 20, 1932. On again examining the culture, two living, vigorous leeches, one young and one mature, were found at the bottom of the jar. Many tiny, young earthworms were found also in the mud. The whole contents, including the leeches, were returned to the jar for further observation.

January 9, 1933. Over four months from the time it was prepared, this leech culture was examined for the third time. Two living leeches were found feeding on young earthworms; they appeared more plump and vigorous than they had been before.

DETERMINATION AS TO WHETHER OR NOT THE FISHES COMMONLY FOUND IN RICE PADDIES FEED ON THE CARABAO LEECH

*Experiment 9.*—March 27, 1932. Four murrels, or dalag, from 28 to 36 cm long, were placed in a large laboratory aquarium, 50 by 30 by 30 cm, together with three young leeches from 3.71 to 5 cm long. Five days later the number of leeches remained the same and the four fishes were still vigorous.

August 10, 1932. Two large dalag, one 35.5 cm long and the other 43 cm long, were placed in the experimental pool together with six leeches from 3.71 to 8.89 cm long. On the second day, one large leech was actually seen chasing and attacking a murrel, but no murrel was observed attacking a leech. Three days later, the pool was drained in order to catch the fish and to count the leeches. One murrel was found bleeding from leech bites over almost the whole body; the other had four bites on different parts of the body. All the original six leeches were recovered.

*Experiment 10.*—April 3, 1932. Two catfishes, or hitó, one 23 cm long and the other 30 cm long, were put in a large laboratory aquarium together with four small leeches, each measuring 3.71 cm long. For eight days it was observed that the number of leeches remained the same.

August 15, 1932. Four catfishes, each 20.5 cm long, were placed in the experimental pool together with four leeches, three of which measured from 3.71 to 6.25 cm long and one 10 cm long. Three days later, the pool was drained. The catfishes were found unhurt, and the four original leeches were recovered.

*Experiment 11.*—April 20, 1932. Two climbing perches, or tinikan, each measuring 12.5 cm long, and three small leeches, each measuring 3 cm long, were put together in a large laboratory aquarium. After thirty-six hours of observation it was found that neither the fish had attacked the leeches nor the leeches attacked the fish.

TO DETERMINE WHETHER OR NOT ANAS BOSCHAS, OR ITEK, FEEDS ON THE CARABAO LEECH

*Experiment 12.*—May 12, 1931. Three leeches, from 5 to 10 cm long, were placed in a large white enameled wash basin containing about a liter of water. The basin was then placed near a flock of eleven ducks. No sooner had the ducks seen the leeches than they fought for them. The smaller leeches were swallowed very easily with a little water. However, the duck that swallowed the largest leech, 10 cm long, twisted its neck several times and drank water at short intervals. Two hours later, this duck was seen going about in search of food as usual.

*Experiment 13.*—April 1, 1932. The walls and the bottom of a cement drinking trough, 60 by 60 by 30 cm, were smeared thickly with dark mud. Water was allowed to flow into the trough to a depth of 15 cm, and two leeches, one 7.5 cm long and the other 5 cm long, were placed in the water. A female duck was put in the trough and it was then covered with chicken wire. It was observed that before the duck was put into the trough the leeches remained quiet and clung to the sides. Upon sensing the presence of the duck the leeches swam about as if to attack the intruder, but they were swallowed by the duck.

This experiment was repeated twice (April 2 and 8, 1932). In each case, however, two ducks and larger leeches were used. When the ducks' bodies were examined after the disappearance of the leeches from the water, neither leech nor leech bites could be found. The ducks were placed in separate cages for observation for one week during which time the birds remained normal.

*Experiment 14.*—April 3, 1932. A female duck was hand fed with two living leeches, each measuring 6.25 cm long. The duck was then put in a cage for observation. Twelve hours later, the entire alimentary canal from the mouth to the anus was slit open; and the mucous membrane, as well as the contents, was examined. Neither pieces of the bodies of the leeches nor points of bites could be found.

*Experiment 15.*—April 4, 1932. A second duck, a male, was hand fed with three living leeches, measuring from 6.25 to 8.89 cm long. Soon after swallowing the leeches, the duck twisted its neck a couple of times and then drank some water. No symptom of trouble was observed thereafter, and the bird was soon feeding as usual. Six hours later the duck was killed, and the entire alimentary tract was slit open. The same results as in experiment 14 were observed.

*Experiment 16.*—April 12, 1932. A third duck, a female, was hand fed with two leeches from 6.25 to 7.62 cm long. Three hours later, the duck was killed and the alimentary tract was examined. The same results as in experiments 14 and 15 were found, except that one bleeding leech bite was observed at the base of the tongue.

*Experiment 17.*—April 18, 1932. A fourth duck, a female, was hand fed with three living leeches each measuring 8.89 cm long. One and one-half hours later, the duck was killed and examined as in the preceding experiments. No leech bite was observed. Two dead leeches were found in the crop already mixed with the feed, and one leech was found partially ground in the gizzard. It was noted that there were twenty-four pebbles in the gizzard of one duck ranging in size from 2 by 3 by 3 to 4 by 5 by 14 mm. For the sake of clarity, the results in experiments 14, 15, 16, and 17 are shown in Table 5.

TABLE 5.—*Showing the results of feeding H. manillensis to Anas boschas.*

| Date. | Duck. | Leeches fed. | Length of leeches. | Time interval. | Leech bite. | Fate of the leeches. |
|---|---|---|---|---|---|---|
| | | | *Inches.* | *Hrs.* | | |
| April 3, 1932 | Duck, female | 2 | 2.5 | 12 | .0 | Digested. |
| April 4, 1932 | Duck 2, male | 3 | 2.5–3.5 | 6 | .0 | Do. |
| April 12, 1932 | Duck 3, female | 2 | 7.5–3.0 | 3 | 1 | Do. |
| April 18, 1932 | Duck 4, female | 3 | 3.5 | 1.5 | .0 | Two dead in crop, one ground in gizzard. |

EXTERMINATION OF LEECHES IN AN INFESTED POOL BY MEANS OF ANAS BOSCHAS

*Experiment 18.*—August 2, 1932. Seven leeches, varying in length from 5 to 7.62 cm, were let loose in the experimental pool. One hour later, three mature ducks, one male and two females, were allowed to swim in the leech-infested pool for eight hours. Then the water of the pool was siphoned off in order to facilitate the search for the leeches. Not a single leech was found after a careful search in the pool.

*Experiment 19.*—August 3, 1932. The pool was again filled with water and seven leeches, varying in length from 6.25 to 8.89 cm, were let loose in it. The three ducks used in experiment 18 were allowed to swim in the pool for three hours. The next day the water in the pool was drained. After a thorough search, two leeches, one large and one small, were found caught

in the flap of a piece of wire netting used for covering the proximal end of the drain pipe. The ducks, evidently, had not seen these leeches, and, even if they had, they probably could not have caught them.

*Experiment 20.*—August 6, 1932. In order to determine whether or not the ducks actually fed on leeches in the infested pool much closer observation was necessary. The experimental pool was again filled with water, and six leeches, varying in length from 6.25 to 11.43 cm, were let loose in it. When the writer dipped his hand in the water of the pool, the leeches swam toward it and attempted to bite it. The three ducks used in the preceding experiments were again allowed to swim in the pool. After five minutes, four of the leeches were seen swimming excitedly around the ducks in their attempt to attack them. On seeing the leeches, the ducks also became excited and began to charge. The smaller leeches were swallowed at once with a little water. The largest leech, measuring 11.43 cm long and about 1.5 cm wide, was caught by one duck. For five minutes, one half of the body of the leech could be seen dangling from the duck's bill. Failing to swallow this large leech, the duck went to the shallowest part of the pool and freed the leech, but instantly caught it again. After many attempts to swallow it, lasting for seven minutes, the duck managed to get it down with the help of a little mud and water. Nothing happened to this particular duck thereafter. Five hours later, the pool was drained and a search for leeches was made, but not one was found.

## DISCUSSION OF RESULTS

Certain dilute solutions of copper sulphate (commercial) can be used to advantage in killing *Hirudinaria manillensis.* As shown in Table 1, a 1 : 50,000 solution killed both the young and mature leeches in from eighteen to seventy-five hours, while a 1 : 100,000 solution killed the young leeches in forty-eight to fifty-seven hours, but not the mature ones, even after a prolonged exposure. A solution of higher concentration than 1 : 50,000 is highly detrimental to the life of this leech. When exposed to a 1 : 10,000 solution, the leech swam excitedly and disgorged most of its stomach contents. About thirty minutes later, the entire body excreted a thick mucoid substance; and about one hour later, both the anterior and posterior suckers lost their power of attachment. The suckers and the genital cones became swollen and hæmorrhagic, the body contracted, then relaxed, and the

annelid died in from two to seven hours. Copper sulphate is an astringent in dilute solutions, caustic in concentrated ones (Milks, 1930). On the basis of the physiological reactions manifested by the annelid, it seems that the 1 : 10,000 copper sulphate solution is both irritating and poisonous to the leech.

A practical method of applying the copper sulphate is by wrapping the drug in a piece of cloth or gunny sack and dragging the bundle over the infested place. Another method is by broadcasting a sufficient amount of powdered copper sulphate on the water so that when the carabaos come to wallow the water will be stirred and the drug uniformly distributed. However, Moore (1923) points out that copper sulphate cannot be used successfully to kill the leeches in the lake, because the toxicity of the drug for the leeches is diminished with the increase in the quantity of minute algæ present.

Table 2 shows that a 2 per cent solution of crude common salt killed both the young and mature leeches in from twelve to seventy-five hours, and a 3 per cent solution killed them in from twenty-two minutes to seven hours. The physiological reactions shown by the leech were apparently the same as those when it was exposed to solutions of copper sulphate. According to Milks (1930), a strong solution of sodium chloride abstracts water from the cells. It may be that, in this case, the leech died through cellular dehydration if not from direct poisoning. As at these concentrations a large amount of common salt is necessary even for a medium-sized carabao wallow, it is not economical to use it as the copper sulphate may be used at much less cost.

If dilute solutions of certain commercial chemical fertilizers had deleterious effects on the carabao leech, the employment of these chemicals would have served a dual purpose in leech-infested rice paddies; but the fact that even a 2 per cent solution cannot kill the young leeches after a long exposure puts these chemicals out of the question.

It is said that when the chopped up fresh roots of namí (*Dioscorea hispida*) are soaked in water in the river in order to remove its poisonous principle, the fishes in that river are killed. The results of the present experiments, however, showed that even a 1 : 100 infusion did not affect the leeches.

Strong tobacco infusions are positively inimical to the life of the carabao leech. A 1 : 600 infusion of tobacco midribs, as shown in Table 3, killed both the young and mature leeches after an exposure of from five to seven days, but a 1 : 100 in-

fusion killed them in from fifteen to forty-two minutes. If tobacco midribs, which are otherwise waste, are available in large quantities, as in Manila, they may be utilized by dumping them into leech-infested places.

As shown in Table 4, infusions of the roots of tibanglan (*Derris elliptica*) are poisonous to the carabao leech, which succumbs to a 1 : 100 infusion in from one to seventeen hours and to a 1 : 1,000 infusion in from twenty-four to seventy-five hours. The active principle in derris, according to Tattersfield and Roach (1922), is nitrogenous-free, nonglucosidal, nonalkaloid, white crystalline derivative and resin to which they gave the name "tubatoxin," and which they claimed to be identical with "tubain" of Wray (1892) and with "derrid" of Sillevoldt (1899). Wray (1892) claimed that the active principle is lost upon drying. But the writer used the air-dried roots in the preparation of the infusions which killed the leeches. The active principle of derris, according to De Ong and White (1924), on the basis of their experiments with insects, is both a stomach and a "respiratory" or tracheal poison. A practical method of applying derris in killing leeches is by scattering a sufficient amount of ground roots in the infested water, thereby dissolving the active principle. Another method is by pounding the roots and then dragging them in the infested water.

*Hirudinaria manillensis* can survive in the bottom of the cracks of dried mud for over three months and in the bottom of their tunnels in constantly wet mud for over five months without showing any change in their vitality. While in this apparently unfavorable environment, they feed on earthworms or other animals therein, so that instead of dying or being in a dying condition their body growth continues unimpaired. This explains why farmers failed in their attempts to control or to exterminate the carabao leech in their rice paddies by draining the fields during the hot season and then burning the rice straw and grass thereon.

The commonest fishes in the rice paddies and pools are the murrel, or dalag; the catfish, or hitó; and the climbing perch, or tinikan. Repeated experiments showed that these fishes do not feed even on very young carabao leeches. On the contrary, the carabao leech attacks the murrel and feeds on its blood. Masterman (1908) reports that in some parts of Palestine the water at the source was kept free from leeches (*Limnatis nilotica*) by means of a kind of carp (*Capoeta fratercula*). If the murrel

fed on *H. manillensis*, it is probable that this annelid would have been exterminated long ago in the Philippines owing to the presence of this fish in places where the carabao leech abounds.

The itek (*Anas boschas*) frequents water, not only because of its mating habit but also for the purpose of searching for food. Repeated experiments showed conclusively that this duck relishes *H. manillensis*. The size and shape of its bill as well as the grinding capacity of its gizzard are well adapted for leech feeding. The pebbles found in the gizzard of this duck are, on the average, very much larger than those found in the gizzard of a domestic hen. As a rule the leeches are swallowed alive, and are killed either in the crop or in the gizzard, as shown in Table 5. One and one-half hours after being swallowed a medium-sized leech is already ground in the gizzard of a hungry duck, and it is digested three hours later. In view of the peculiar feeding habit of the duck of swallowing its food with much water, small leeches, when swallowed, seem to swim their way through the œsophagus into the crop of the bird. Large leeches, however, are swallowed only with difficulty. In spite of this, the duck does not give up until even the largest is swallowed.

Owing to the fact that *H. manillensis*, especially the mature one, is attracted by the hot-blooded animals, the carabao leech is attracted by the duck just as much as it is attracted by the carabao. The leeches, upon sensing the presence of the ducks in their habitat, swim towards the birds to attack the intruders but are themselves swallowed by the ducks. Repeated trials have shown that the itek (*Anas boschas*) is a very efficient agent in getting rid of the leeches in an experimentally infested pool.

## SUMMARY AND CONCLUSION

1. Since the 1 : 50,000 solution is the weakest solution of copper sulphate found to be deleterious to both young and mature *Hirudinaria manillensis*, a solution of approximately this concentration may be employed in the destruction of leeches in pools and rice paddies by either broadcasting a sufficient amount of the powdered drug on the water or by dragging a bundle containing copper sulphate through the infested water.

2. Commercial chemical fertilizers, at least those mentioned in this paper, are not harmful to the carabao leech even at a 2 per cent concentration.

3. If the infested place is very limited in area, as a carabao wallow or a pool, a sufficient amount of crude common salt may

be broadcast on the premises to make, approximately, a 2 or 3 per cent solution.

4. Since a 1 : 400 infusion of tobacco midribs killed the carabao leech in from twelve to twenty-four hours, the midribs, which are otherwise waste, can be utilized by scattering them in infested pools to kill the leeches.

5. As a 1 : 100 infusion of tobacco and a 5 per cent solution of crude common salt are both highly inimical to the life of *H. manillensis,* killing it in from ten to forty-two minutes, these preparations should be very useful in dislodging the leeches from any part of a body, particularly from the inside of the nostrils of a carabao.

6. *Derris elliptica* infusion is markedly poisonous to the carabao leech as it is to fishes, as shown by the fact that a 1 : 1,000 infusion can kill this leech in from twenty-four to seventy-five hours; and in view of the availability of this plant, its use in the control of leeches should be practical and economical.

7. *Hirudinaria manillensis* can survive in the bottom of dried mud for over three months and in constantly wet mud for over five months, which periods are longer than the time covered by the hot season in the Philippines.

8. The experiments showed that the commonest fishes in the rice paddies and pools, such as the murrel, the catfish, and the climbing perch, do not prey upon even the smallest carabao leech.

9. The itek, or bebe (*Anas boschas* Linn.), is anatomically and physiologically adapted for feeding on leeches, and repeated experiments conclusively showed that this duck relishes *H. manillensis.*

10. As the itek relishes the carabao leech and diligently searched for it in infested pools, raising this duck in leech-infested places, which are otherwise neglected, will help in the control or extermination of leeches.

## ACKNOWLEDGMENT

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# ILLUSTRATIONS

PLATE 1

FIG. 1. *Hirudinaria manillensis,* mature, dorsal and ventral views, × 1.
2. *Hirudinaria manillensis,* young, dorsal view, × 1.

PLATE 2

FIG. 1. *Anas boschas,* male and female, × 1/13.
2. Experimental pool with three ducks swimming in its water.

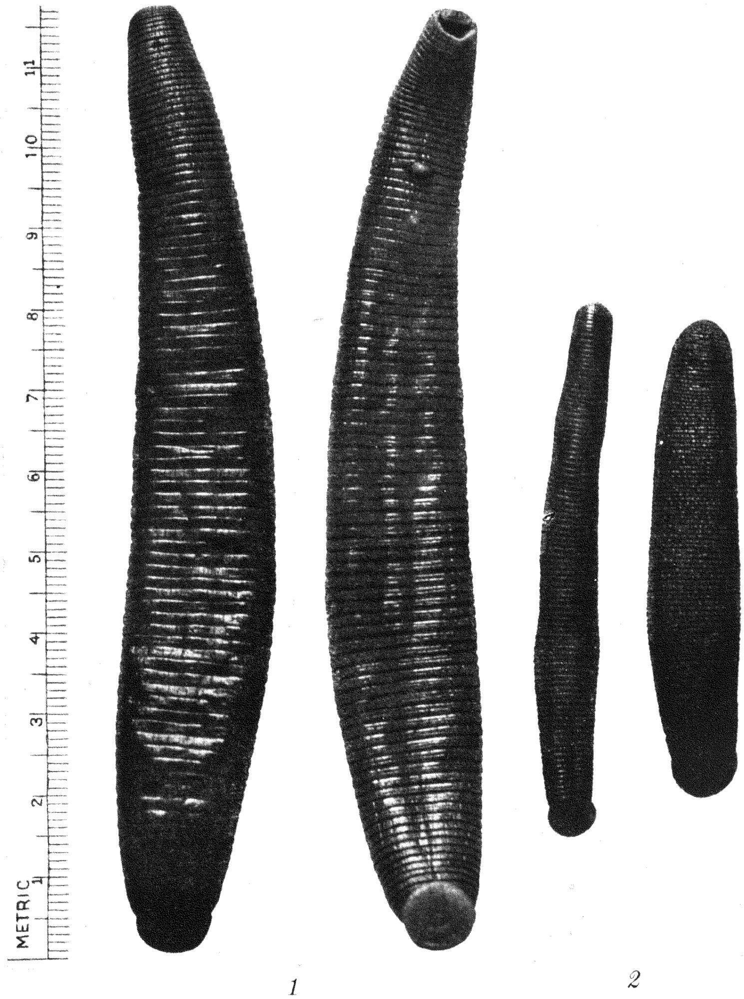
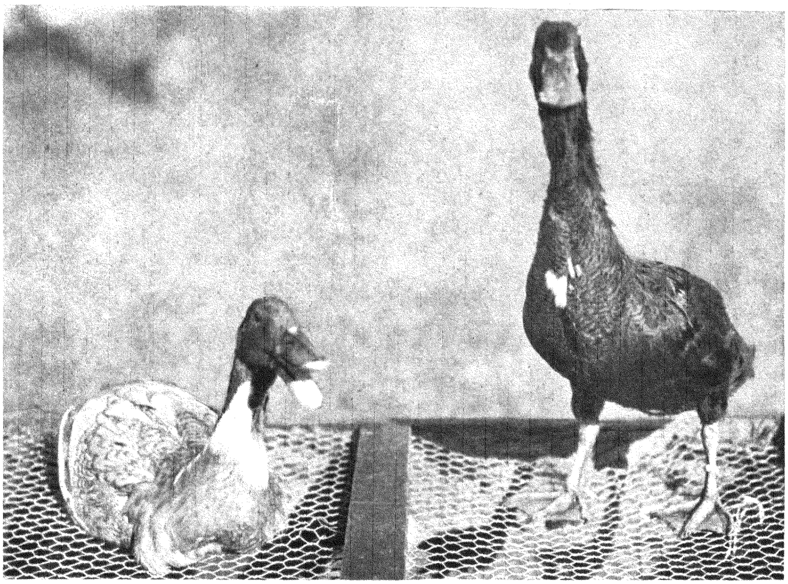



PLATE 1.



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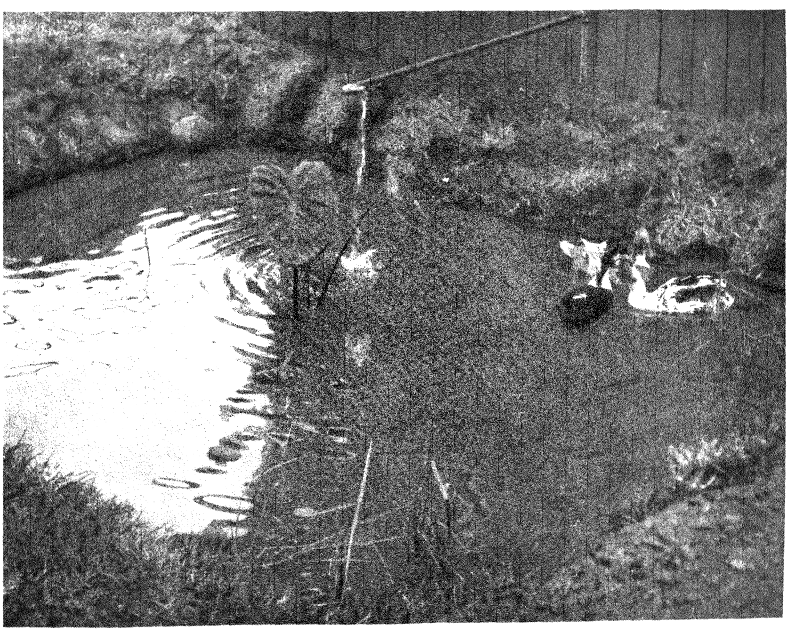

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PLATE 2.

# PLANT-DISEASE PROBLEMS CONFRONTING TRUCK FARMERS IN TRINIDAD VALLEY AND THE VICINITY OF BAGUIO, MOUNTAIN PROVINCE, PHILIPPINE ISLANDS [1]

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TWENTY-FIVE PLATES

Because of their semitemperate climate, Trinidad Valley and the environs of Baguio, Mountain Province, constitute one of the few regions in the Philippines where semitemperate crops can be grown successfully, and where truck gardening is extensively practiced. Fresh vegetables raised in this region find a ready market in Baguio, Manila, and nearby provinces, and as a result of this and the favorable climate, the acreage under cultivation for vegetables has greatly increased in the past ten to fifteen years, so that the yearly income from vegetables alone is conservatively estimated at several thousand pesos.

The farmers at present, in order to meet the demand for fresh vegetables, grow them extensively in succession or in short rotation throughout the season, growing plants of the same or closely allied families on the same piece of ground. Furthermore, instead of raising their own seeds, the vegetable growers find it more practical and profitable to buy them from other countries. With such farming practices, and the rather long, mild, moist season, the increase in the severity and distribution of indigenous diseases and the introduction of foreign parasites which can adapt themselves to these regions are inevitable. The farmers of this locality, therefore, are confronted not only with various soil-deficiency problems, but also with numerous plant diseases and pests which seasonally or annually destroy all or part of their crops.

[1] This work was done while the writer was connected with the Bureau of Science.

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Therefore, a survey of these plant diseases seems of considerable interest.[3] This paper principally aims to report and enumerate the occurrence of the important and common diseases of various garden crops grown in Trinidad Valley and the environs of Baguio, Mountain Province, with the hope that a detailed investigation may be conducted in the future on the etiology, epidemiology, and control of each of the maladies mentioned herein. For the purpose of the present studies, the host plants are divided into groups and their diseases are listed and briefly described in the order of their importance.

## DISEASES OF CRUCIFEROUS CROP PLANTS

Most of the members of the cruciferous crop plants are grown successfully in these regions. The cabbage is the most important and most widely grown, followed by the Chinese cabbage "wongbok," cauliflower, pechay, broccoli, radish, turnip, mustard, and Brussel sprouts.

### DISEASES OF BROCCOLI AND BRUSSEL SPROUTS

Broccoli and Brussel sprouts are minor crops in the Mountain Province. Leaf spot, due to *Alternaria brassicæ* (Berk.) Sacc., is a common, but not a serious disease. The lower leaves are usually affected. The spots are usually light brown to dark brown with concentric rings.

### DISEASES OF CABBAGE

Cabbage is the most extensively grown vegetable crop in Trinidad Valley and in other localities of the Mountain Province. As a single crop, the value of cabbage produced in the valley is estimated at several thousand pesos annually. The common diseases of cabbage are black leg [*Phoma lingam* (Tode) Desm.], black rot [*Plytomonas campestris* (Pammell) Bergey et al.], soft rot [*Erwinia carotovora* (Jones) Holland], and leaf spot [*Alternaria brassicæ* (Berk.) Sacc.].

*Black leg* (*Phoma lingam*).—In 1929, this disease was observed as common on most farms in Trinidad Valley, Lucban, Quisad, and Camp 7, causing 5 to 20 per cent infection. Since then, it has increased in severity and distribution, having appeared in almost every farm in Trinidad Valley. In September, 1932, it was found at Haight's Place, Mountain Trail, 52 kilometers

[3] The first plant-disease survey was started late in 1929 and has been continued from time to time up to the present.

from Baguio, where cabbage and other garden crops are also commercially grown. The disease is present all the year around, but most prevalent during the early and late parts of the season, when the weather is warm and moist. The fungus attacks plants at any stage of growth and causes blackening or rotting of the stem or spotting of the leaves (Plate 1 and Plate 2, fig. 1). As a result of the infection on the stem the disease in the early stages causes the lower leaves of the infected plants to turn bluish red, but as the rotting on the stem progresses, the plant gradually wilts and finally dies; if, however, the infection on the stem is slight, the plant may fail to form a head. From the infected stems and leaves, pustules (pycnidia) of the fungus are developed (Plate 1, figs. 1 and 2, and Plate 2, fig. 1).

The cabbage varieties commonly grown and susceptible to the disease are Early Market, Flat Dutch, American Red, Succession, and Shanghai. Among these the Shanghai variety is most resistant to the disease. This variety, although successfully grown during the normal cabbage season, is generally planted when the crop is subjected to more rains than usual. It is a late variety and a heavy yielder. The organism is known to be carried on or in the seed, and undoubtedly the disease was introduced with the cabbage seeds some years ago from other countries where it is serious on cabbage. It is now established in this locality, and unless its spread is checked, it eventually may ruin the cabbage industry in the Mountain Province.

*Black rot* (*Phytomonas campestris*).—This is a common disease of cabbage and other cruciferous plants in these regions, where in some cases 100 per cent infection was observed in the field. The characteristic symptom of the disease is blackening of the veins from the margins of the leaves; later the tissues turn yellow and dry up, especially when the weather is dry (Plate 2, fig. 2). As the disease progresses, blackening of the veins of the vascular bundles extends downward to the stem, and from there infection follows the vascular system up and down the plant, thus infecting the other leaves, as is usually shown by the blackened veins of (some) inner leaves in the formed head. In some cases as a result of infection, the leaves turn yellow, wilt, and then fall off from the bottom up to the stem so that a diseased plant may show merely a bare stalk with tufts of leaves on top. Such plants are stunted and may fail to produce heads.

Contaminated soil, seed, manure, and plants are the chief carriers of *Phytomonas campestris,* and once introduced into the

field, the bacteria will long remain active in the soil and ready to infect cabbage or other cruciferous crops grown thereon. As the disease is carried with the seed it was probably introduced some years ago with contaminated seeds from abroad.

*Soft rot* (*Erwinia carotovora*).—This is a serious and a common disease of cabbage in the field, in transit, or in storage. It is recognized by the transformation of the affected part into soft, wet, pulpy masses, often giving off an offensive odor. All the cabbage varieties grown in the valley are susceptible to soft rot. This disease is more serious on crops harvested early or late in the season or on crops subjected to abundant moisture and warm temperature. Under such conditions, a big cabbage head may be rotted within a few days (Plate 2, fig. 4) and a loss of 10 to 25 per cent or more of the crop may be observed. In storage or shipment this trouble also seriously affects cabbage and other vegetables.

*Leaf spot* (*Alternaria brassicæ*).—This disease is found common in most cabbage farms in these regions (Plate 2, fig. 3). It causes spotting of the leaves with the characteristic black, circular, and concentric rings. It usually is not serious, as it generally affects the old leaves, but in neglected plots all except the inner leaves of the head become heavily spotted. In this case all or part of the leaves dry up. The spots vary from a dot to over 1 centimeter in diameter.

### DISEASES OF CHINESE CABBAGE, "WONGBOK"

The Chinese cabbage, or "wongbok," is an important vegetable crop and is generally grown in Trinidad Valley. This crop is affected by certain diseases which give farmers much trouble.

*Gray leaf spot* (*Alternaria herculea Ell. and Mart.*).—The leaf-spot disease caused by *Alternaria herculea* is a very common and serious disease of "wongbok" in the greenhouse and in the field, causing 100 per cent infection. It is present all the year around, but most serious during warm, moist days, when the leaves become badly spotted (Plate 3). When these conditions are followed by warm, bright days, badly infected leaves dry up and become papery, as if the plant had been scorched by flame. In this case 20 to 50 per cent of the leaves may be culled from single mature plant with a head. The progress of the disease is somewhat checked during dry weather, when the infected tissues dry up and fall off, causing a shot-hole effect. Dry hot weather is not favorable to the disease, and a good crop may be obtained without the excessive use of protective spray. A simi-

lar disease was reported by Weimer in California where it is only of minor importance. Undoubtedly, this disease is also not indigenous in this country.

Soft rot (*Erwinia carotovora*), although a minor trouble of "wongbok," is common during warm weather. Damping-off is a common disease of seedlings in the greenhouse. *Rhizoctonia* species and *Pythium* species are the two fungi usually found in association with damping-off in the seedbeds in Trinidad Valley and in the vicinity of Baguio. Mosaic was found on "wongbok" in Trinidad Valley but was not common.

### DISEASES OF CAULIFLOWER

The cauliflower, not as widely grown as cabbage or Chinese cabbage, is also subject to the common diseases of cabbage; namely, common leaf spot (*Alternaria brassicæ*), soft rot (*Erwinia carotovora*), and black leg (*Phoma lingam*).

The leaf-spot (*Alternaria brassicæ*) though common on the leaves and on the curd, is usually not serious (Plate 4). On the curd the fungus causes the infected regions to blacken and rot, and this tendency is encouraged by the method practiced in the valley for bleaching the curd. On the leaves the disease causes dark brown spots of varying size. Under neglected conditions it may cause serious spotting and drying up of a great portion of the leaves. This disease was observed also in Haight's Place, Mountain Province. Soft rot (*Erwinia carotovora*) is serious late in the season, when the weather is warm and moist. It is generally found in Trinidad, the vicinity of Baguio, and Haight's Place, Mountain Province. Black leg (*P. lingam*), also found on cauliflower, is of minor importance. This host seems to be more resistant than cabbage, as the infected plants suffer less.

### DISEASES OF PECHAY

Pechay is usually grown as a crop for early or late season when it is too wet for successful growing of any other crop. The common diseases observed are the leaf spots caused either by *Cercospora brassicicola* Henn., or by a species of *Alternaria* [*Alternaria brassicæ* (Berk.) Sacc.?], white rust, caused by *Albugo candido* (Pers.) Ktz., and mosaic (virus). The two leaf-spot diseases caused by *Cercospora* and *Alternaria* are the important diseases of pechay, causing considerable spotting and dying of tissues on the leaves. The spots due to *Cercospora* are usually pale, papery, and slightly sunken (Plate 5, fig. 1),

while those due to *Alternaria* are usually characterized by light brown to brown spots with concentric rings (Plate 5, fig. 2). White rust (*Albugo candido*) is common but not generally serious. It affects the leaves, pods, or flower stalks, causing malformations on the infected regions. The disease is recognized by the presence of pustules (sori) with white masses of spores which are usually produced on the lower surface of the leaves or on the pods and stem. It was found also affecting shepherd's purse, radish, mustard, turnip, water cress, and a species of *Amaranthus*. Mosaic is not as serious on pechay in these regions as in the Chinese gardens in Manila, where 30 to 50 per cent infection or more was found.

#### DISEASES OF MUSTARD

Mustard is a minor crop. The variety usually grown is the Shanghai mustard. A leaf spot caused by *Alternaria* spp. was found attacking this plant. This disease is serious, especially on farms where spraying is not practiced.

#### DISEASES OF RADISH

The American red and the Chinese and Japanese white radishes are the ones generally grown, but on a limited scale. A leaf spot due to *Alternaria* sp. (*A. brassicæ?*) is the commonest disease found, although it is not usually serious on radishes. A disease that causes spotting and rotting of the fleshy root was observed but is generally not serious.

#### DISEASES OF TURNIP

Turnip is cultivated on a small scale. A leaf-spot disease due either to *Alternaria herculea* Ell. and Mart. or *Alternaria brassicæ* (Berk) Sacc. is common in Trinidad Valley and Haight's Place. These are generally minor diseases of turnip, but they become serious in neglected gardens (Plate 6).

### DISEASES OF CUCURBITACEOUS CROP PLANTS

#### DISEASES OF CHAYOTE

The cucurbitaceous crop plants represented by chayote, cucumber, squash, and upo are not generally grown on as large a scale as the cruciferous plants.

Chayote, a recently introduced vegetable crop, is becoming more widely grown in Trinidad Valley, and in other localities

near Baguio. This crop has not been found affected with many diseases. A leaf spot of minor importance, due to *Cercospora*, has been found, most frequently on the older leaves.

### DISEASES OF CUCUMBER

The American cucumber is grown commonly in Trinidad Valley, where it is generally planted in April and May. The downy mildew [*Peronoplasmopara cubensi* (B. and C.) Clinton] is the most serious disease of cucumber, causing 100 per cent infection in the field. This disease is serious during cold and moist weather (November to January and May and June), but less common during the drier months (February to April). It produces irregularly shaped yellowish spots on the surface of the leaves.

On the under surface of the leaves, the spots are brownish to purplish and spores of the fungus are abundantly produced. The affected leaves sooner or later dry up. The older leaves nearest the center of the hill show the worst drying, stunting the plants which in turn produce small, poorly developed fruits. The mosaic (virus) disease of cucumber, although frequently found, is not serious. Powdery mildew (*Erysiphe* spp.) was also found but is of minor importance on cucumber.

### DISEASES OF SQUASH AND UPO

Squash and upo are minor crops grown only in small plots. Mosaic (virus) was found on upo and on American Summer, and native, squash but is usually not serious. The American Summer squash appeared to be more susceptible to mosaic than the native variety. The affected plants show marked puckering, mottling, and clearing of the leaves, and as a result the plants are stunted and fail to yield fruits. This is true especially in the case of plants infected severely while they are still young. Powdery mildew (*Erysiphe* spp.) is also found on native squash but does not cause very great damage.

### DISEASES OF THE LEGUMINOUS CROP PLANTS

The leguminous crop plants are considered next in importance in the extent of cultivation to the cruciferous groups. The garden beans and peas are the two most important legume crops generally cultivated on most farms in this locality. Soybean and peanuts are cultivated only on a very limited scale.

DISEASES OF BEANS

The garden bean is generally grown throughout the season in Trinidad Valley and in other localities near Baguio. The angular leaf spot (*Isariopsis griseola* Sacc.), bean rust [*Uromyces appendiculatus* (Pers.) Lev.], anthracnose [*Colletotrichum lindemuthianum* (Sacc. and Mag.), Bri. and Cav.], stem rot (*Sclerotium rolfsii* Sacc.), damping-off (*Pythium* and *Rhizoctonia*), powdery mildew (*Erysiphe* spp.), and bean mosaic (virus) are commonly found on the bean.

*Angular leaf spot* (*Isariopsis griscola*).—This is a very serious disease affecting the leaves, stems, and pods. The lesions on the leaves are small angular brown spots usually delimited by the veins or veinlets (Plate 7, fig. 1). Numerous and severe infections on the leaves cause them sooner or later to dry up and fall off prematurely, defoliating the plant before it reaches the fruiting stage. The disease is serious during the early and late seasons when the weather is moist and warm. If infection is early and the weather favorable, plants become stunted or die and no pods may be gathered. Kentucky Wonder, Chinese Wax, Chinese black bean "luvias," Bountiful, Canada Wonder, and Genuine Cornfield were all found to be susceptible to the disease. The black bean, or luvias,[4] however, appeared to be more resistant than the other varieties. The fruiting structures of the fungus, which are small and black, are found in great numbers on the dead areas of the undersurface of the leaves. This disease is not endemic as it has not been found in other localities in Mountain Province.

The bean rust (*Uromyces appendiculatus*) is as serious on garden beans as the angular leaf spot. It is common, although most prevalent and serious during the drier months of the year. The rust pustules containing orange powdery masses are developed on any part of the plant, but they are more numerous on the leaves. When infection on the leaves is heavy, the plant is stunted or defoliated (Plate 8, fig. 1). All the varieties of the garden bean (*Phaseolus vulgaris* L.) grown in the locality are susceptible. Among the pole-bean varieties, the Chinese black bean, or luvias, is most resistant. The Kentucky Wonder is found to be very susceptible. In general the pole-bean var-

[4] This variety is commonly grown and has been cultivated in this region for some time. Its apparent natural resistance has perhaps been built up through continuous selection. The other varieties are of recent introduction.

ieties are more susceptible than the bush-bean varieties. No record of bean rust has heretofore been reported, but the disease is believed to have been introduced into the Islands.

*Bean anthracnose* (*Colletotrichum lindemuthianum*).—This disease was first noted in 1929 in Pacdal, and Guisad, Baguio, but in later survey infected pods were brought at various times by native farmers for sale in the markets of Baguio, indicating that the disease is more widely distributed in these regions.

The greatest damage is to the pods, which become unmarketable. It produces sunken dark brown to blackish spots which may be round or oval with a reddish margin, and when the weather is moist, pinkish spore masses develop from these spots (Plate 8, fig. 2). On the underside of the leaves, especially along the veins, it causes reddish brown to black-brown lesions, while on the seed yellowish to brown or black spots are produced. Plants at any stage of growth are attacked, and if infection occurs when the plants are young and under favorable conditions of cool moist weather, the disease may ruin the crop. As the fungus is known to be carried in the seed it was undoubtedly introduced into these regions some years ago with infected seeds.

*Stem rot* (*Sclerotium rolfsii*).—This fungus, causing rotting of the stem and finally death of the plant, was noted in 1930, but it has been found since then on various other garden crops in the agricultural school garden. It is recognized by the rotting of the stem, on which thick masses of white mycelia and small brown sclerotia about the size of mustard seeds are found. It is, however, still a minor disease on beans.

*Damping-off* (*Pythium and Rhizoctonia sp.*).—These are the two common fungi causing damping-off of young bean plants in the field. The extent of injury is more serious when beans are sown during the relatively wet season.

*Powdery mildew* (*Erysiphe spp.*).—This fungus is occasionally found on beans, but its effect is not as serious on them as on peas. It affects the leaves, pods, and stems, producing white powdery masses on the lesions. The affected leaves die prematurely, and the productiveness of the plant is greatly reduced. The worst damage, however, is the serious stunting of the plants or the rendering unmarketable of the infected pods. This disease becomes commoner during the drier months of the year.

Bean mosaic (virus) was observed in the valley in 1929 on the dwarf Japanese wax bean and on the pole Chinese black

bean where infection was estimated at 25 to 50 per cent. Mosaic plants are less productive, and under severe infection plants are stunted and may fail to produce pods. The disease is not yet serious but is becoming widespread in these regions.

General mottling, crinkling, cupping, or puckering symptoms on the leaves are characteristically produced during the warmer months (Plate 7, fig. 2), but when the weather becomes cooler and moister, these become less evident. The Chinese black and the Chinese wax beans showed more resistance to mosaic than any of the bean varieties grown in this region. This disease is known to be hereditary and, as it is carried in the seed, it has undoubtedly been introduced into these regions with the importation of foreign seeds. The spread of the disease to other localities is largely effected by insects and through infected seeds.

### DISEASES OF THE PEA

Both the American and the Chinese "chicharo" peas are generally grown. The common diseases found on them are the ascochyta leaf blight [*Mycosphaerella pinodes* (B. and Bl.) Stone], powdery mildew (*Erysiphe* spp.), and tip burn (physiological).

The ascochyta leaf blight (*Mycosphaerella pinodes*) is the most serious disease of peas affecting plants at any stage of growth. It causes spotting or blotching and finally blighting or death of the leaves. When the weather is warm and moist, young severely infected plants die and the majority of the leaves of bearing plants dry up (Plate 9). The pods may be malformed or spotted, depending upon their age at the time of infection. The disease is most serious when the season is warm and moist, and this is especially true with crops sown early or late in the season when the weather is moister than usual. The American and the Chinese ("chicharo") peas are both susceptible to the attack of the disease, but the Chinese peas show more resistance than the American variety.

Powdery mildew (*Erysiphe* spp.) is a common disease of peas, affecting the leaves, stems, and pods and producing spots or lesions. This fungus is recognized by the white, powdery appearance of the affected parts. It is serious during March and April, when the season is usually dry. When infection is early and severe, the plants may die or become unproductive.

Tip burn is a physiological trouble of peas, usually developed on the tender leaves after a few days of rain followed by hot,

bright days. This trouble is not serious, but plants are set back by it.

### DISEASES OF THE PEANUT

The peanut is not usually grown in the valley, but plants grown in test plots of Trinidad Agricultural School were found badly affected by leaf spot (*Septogloeum arachidis* Rac.). Seriously affected plants are heavily defoliated and greatly stunted in growth. This was the first time peanuts were planted at the agricultural school. Since it was learned that the original seeds were obtained from the lowlands, there is no doubt that the disease was introduced.

### DISEASES OF THE SOY BEAN

The soy bean is not a regular crop in this region but was grown primarily for its value as a green manure. In the trial plots of the Bureau of Plant Industry and of the Trinidad Agricultural School the soy-bean rust (*Uromyces sojæ* Sydow) was common and caused considerable injury.

## DISEASES OF SOLANACEOUS CROP PLANTS

The solanaceous crops cultivated in this vicinity such as potato, tomato, eggplant, and pepper are not as extensively grown as cabbage, garden beans, or garden peas, not because there is no market for them but because their culture has become less profitable due to the presence of serious diseases.

### DISEASES OF THE EGGPLANT

The eggplant grows successfully, but is raised only on a limited scale. The Japanese eggplant is generally cultivated in Trinidad Valley. The leaf spot [*Phomopsis vexans* (Sacc. and Syd.) Harter], bacterial wilt [*Phytomonas solanaceara* (Erwin Smith) Bergey et al.], stem rot and fruit rot (*Sclerotium rolfsii* Sacc.), and cracking of fruits (physiological trouble) are the diseases found on the eggplant.

The leaf spot (*Phomopsis vexans*) was observed at Trinidad Agricultural School, causing 100 per cent infection in one of the eggplant plots. The disease causes considerable spotting and dying of the tissues, thus producing "shot-holes" on the leaves. During warm, moist days, severe field infection is noted, and infected plants may be completely defoliated. The American, the Japanese, and the Philippine eggplants are equally susceptible.

Stem rot (*Sclerotium rolfsii*), killing young and old plants, is usually found, although generally not a serious disease. This fungus has also been found rotting the fruits that were touching the ground. This disease is recognized by the presence of white masses of mycelia or of numerous small brown sclerotia on the infected stem or fruit. The bacterial wilt (*Phytomonas solanaceara*) was observed in 1930 to be serious in Camp 7, and in 1931 and 1932 it was found in Trinidad Valley. This trouble is recognized by the gradual wilting and final death of plants with no external indication of the disease on the stem or roots. When such plants are pulled off and the roots cut, a shiny bacterial ooze may be observed from the cut ends of the vascular bundles. Cracking of the fruit (physiological trouble) is common on eggplants that are subjected to frequent rains late in the season. This is a physiological trouble apparently due to excessive moisture.

### DISEASES OF PEPPER

Both the sweet and the hot pepper varieties are grown. Mosaic (virus), stem rot (*Sclerotium rolfsii*), bacterial wilt [*Phytomonas solanaceara* (Erwin Smith) Bergey et al.], and fruit rots (due to *Bacteria, Alternaria, Macrosporium,* and *Phoma*) are the diseases found on pepper.

Mosaic (virus) is found to be quite general, causing 100 per cent infection in some fields. Mosaic plants showed various types and degrees of mottling and clearing symptoms. This disease affects the photosynthetic activity of the leaves; the loss in yield, therefore, is dependent upon the earliness of infection and the severity of leaf symptoms. The American pepper, the Mexican hot pepper, and the Philippine native peppers were found susceptible.

Stem rot (*Sclerotium rolfsii*), bacterial wilt (*Phytomonas solanaceara*), and fruit rots due to *Bacteria, Macrosporium, Alternaria,* and *Phoma,* even if found, are minor diseases of pepper at present.

### DISEASES OF THE POTATO

The potato was once said to be the staple crop generally grown in Trinidad Valley and other localities in the Mountain Province. Because of certain diseases, however, potato culture is now limited and cannot be carried on with profit. The diseases found on potato are the late blight [*Phytophthora infestans* (Mont.) De Bary], potato scab [*Actinomyces scabies* (Thax.) Gussow], rhizoctonia (*Corticium vagum* B and C.), early blight [*Alter-*

*naria solani* (E. and M.) Jones and Grout], and storage rots (fusarial and bacterial species).

The late blight (*Phytophthora infestans*) is the most destructive disease of the potato (also tomato) in the Mountain Province but has not yet been observed in the lowland provinces. It was noted in 1929, but it is believed that it has been in Trinidad Valley (4,263 feet) and in the vicinity of Baguio (4,989 feet) for some years.[5] In a limited survey the disease was also found in Antamok, 2,500 to 3,000 feet elevation; at Acop's Place, 4,300 to 4,500 feet; and at Haight's Place, Mount Paoay, Benguet, 7,350 to 8,000 feet, indicating that the disease is now widely distributed in the mountain regions, where the altitude is high.

The fungus attacks the tubers and all aërial parts of the plant. The lesions on the tubers are characterized by slightly shrunken, purplish brown spots. On the leaves the disease manifests itself as water-soaked brown lesions, usually starting from the margin or edge of the leaflets, and gradually or rapidly involve the whole leaf, depending upon the weather conditions. On the stem identical brownish lesions are produced. From the lesions on the leaves, stems, or tubers the fruiting bodies of the fungus, appearing as "white tuffs," are developed. When the weather is dry or sunny the progress of the disease is retarded and the infected leaves shrivel up, but when the weather is cool and moist, especially when there are a few days of rain, it spreads rapidly, so that the infected leaves, stems, and other parts are killed within a few days. Under these favorable weather conditions the whole potato field may be ruined in less than a week (Plate 10).

The late blight organism is known to be carried with infected tubers and undoubtedly was introduced into the Philippines from abroad. Its presence in other localities of the Mountain Province obviously is due to the use of contaminated tubers. The spores of the fungus are developed in great numbers and readily carried by wind, water, and other means, which may account for the rapid spread of the disease during favorable conditions in the field.

Potato scab (*Actinomyces scabies*) is quite prevalent in most farms in Trinidad Valley. From field counts made of small potato plots in 1932 at Kilometer 4, Trinidad Valley, about 50

[5] As this disease is usually serious after a few days of rain, the farmers of this region usually blame the rain as the cause of their potato crop failure.

per cent of the crop showed scab infection. The disease is characterized by spots or scabbed lesions, which disfigure the appearance of the tubers (Plate 11, fig. 4). All potatoes grown in Trinidad Valley are susceptible, but the red-skinned ones appeared to be less affected by the disease. The fungus is carried with the tubers and no doubt it also was introduced from abroad.

The rhizoctonia disease (*Corticium vagum*) has been found common on both native and imported potatoes offered for sale in the Baguio market. Infected tubers may be recognized by the presence of black sclerotia or "dirt which does not wash off" on the surface of the potato (Plate 11, fig. 3). When infected tubers are used for planting, the sclerotia of the fungus become active and attack and kill the young sprouts as they come up or produce sunken colored lesions on the stems. Plants with lesions on the stem are generally weak; and because of the injury on the stem the tubers, which are normally produced underground, may develop aërially along the stem.

This disease does not yet assume as important proportions as other maladies mentioned above, but in other countries, the rhizoctonia disease is considered very important on potato. The causal organism is carried as "sclerotia" on the tubers, and no doubt it has been introduced into the Philippines in this way. Once the organism is introduced, it remains active in the soil for many years, either living as a saprophyte on dead tissues or as a parasite on other living susceptible plants.

*Mosaic* (*virus*).—The mild and rugose type of mosaic is widespread and is found in many farms in Trinidad Valley and in various places near Baguio. In some farms it is not uncommon to find potato fields with 10 to 25 per cent infection from infected tubers. In 1932 it was found on volunteer plants at Haight's Place and on one of the gardens at Antamok Gold Field. Mosaic plants show the typical mottling, crinkling, or puckering symptoms of the leaves. This disease is one of the most serious diseases of potato in the United States, but it is not yet a serious problem on potatoes in this region. It is perpetuated in diseased tubers, and its occurrence in the Philippines must be traced to imported diseased tubers. Insects (aphids) are known to transmit it to healthy plants in the field.

*Stem rot* (*Sclerotium rolfsii.*)—This fungus causes rotting of the stem near the soil line, and the death of the plant results. This fungus is also found causing rotting of tubers in the field or in storage. It is recognized by the presence of white masses

of mycelia or of round brownish sclerotia about the size of a mustard seed on or near the infected regions. Other plants besides the potato have been observed affected by this disease.

Early blight (*Alternaria solani*) was found at Guisad, Baguio, in Trinidad Valley, and in Haight's Place, Mountain Province. It appears only occasionally, and when present causes little injury. It may be recognized by brown circular or oval spots on the leaves, which may show concentric rings.

Soft rot (*Erwinia carotovora*) and dry rot (*Fusarium* sp.), only of minor importance at present, are common storage troubles of the potato.

### DISEASES OF THE TOMATO

The tomato grows well in the Mountain Province and has commercial possibilities. As in the case of potatoes, however, because of certain diseases its culture is now limited to the extent of being often omitted in the seasonal rotation of crops. The diseases commonly found are late blight [*Phytophthora infestans* (Mont.) De Bary], tomato wilt [*Phytomonas solanaceara* (Erwin Smith) Bergey et al.], mosaic (virus), top wilt and spot necrosis (cause unknown), fern leaf (virus), powdery mildew (*Erysiphe* sp.), root knot [*Heterodera radicicola* (Greef) Muller], stem rot (*Sclerotium rolfsii* Sac.), fruit rots (bacterial, fusarial, and sclerotial causes), and early blight [*Alternaria solani* (E. and M.) Jones and Grout].

The late blight (*Phytophthora infestans*) is also a serious disease of tomato as on potato, and the limiting factor in the successful cultivation of tomato in Trinidad Valley and in other localities of Baguio, Mountain Province. This disease assumes epiphytotic severity when the weather is cool and wet, ruining the whole field in a few days. All the vegetative aërial parts of the plant, including the fruit, are affected by the disease (Plate 12, and Plate 14, figs. 1 and 2). The symptoms of the disease on the aërial parts are almost identical with those found on the potato, while on the fruits the lesions are usually light brown, firm, and somewhat sunken. Under severe infection late in the season from 50 to 80 per cent of the fruit may be ruined by the disease (Plate 14, figs. 1 and 2).

The Giant Ponderosa, Dwarf Champion, New York Dwarf Champion, and the native varieties that are commonly grown are found very susceptible to the blight. The disease has been observed since 1929, although it is believed to have been here some

years ago. Whether the tomato and potato are affected by the same fungus cannot be definitely stated at present, but studies on these two late blight diseases are in progress.

Tomato wilt (*Phytomonas solanaceara*) was noted on a few tomato plants at Trinidad Agricultural School during the season of 1929–30. In 1932 it was observed to be more serious on the same plot, 50 per cent or more of the tomato plants having wilted and died due to wilt. This disease is serious in the tomato-growing regions in the lowland provinces; and, no doubt, may also become an important disease of the tomato in these regions. The infected plants gradually wilt, and finally die. No tomato variety is yet known to be resistant to this disease.

Mosaic (virus) on tomato is usually not a serious disease in the field in Trinidad Valley or in the tomato fields in the lowland provinces. A serious outbreak of mosaic, however, was observed in 1932–33 in the greenhouse at Trinidad Agricultural School, where all the commercial American and Philippine tomatoes showed 100 per cent infection. Plants infected showed typical mottling and clearing of the leaves (Plate 13, fig. 1).

*Top wilt and spot necrosis* (*cause unknown*).—A new malady not yet observed in the field was noted in November, 1932, at the time when mosaic was found in the greenhouse of Trinidad Agricultural School. The disease manifests itself either as small necrotic areas (spots) on the young leaves of the infected shoot, or such leaves become light green, stiff, gradually wilt and then finally dry up, leaving the older leaves of the shoot unaffected.

The disease is considered more serious than that of mosaic, (virus) as it causes not only the young shoots but also the flowers to dry up and fall. All the varieties of tomato grown in Trinidad are susceptible. No organism causing the trouble has yet been isolated. Although in certain stages the disease shows some of the symptoms of the Australian spotted wilt disease of tomato, it cannot be considered as the same until further investigations have been made.

Fern leaf (virus), a minor disease of tomato (Plate 13, fig. 2), was noted in Antamok, Baguio, and in the greenhouse of Trinidad Agricultural School. This is also a minor disease of tomato in the lowland provinces.

Powdery mildew (*Erysiphe* spp.) is rarely found on tomato in the field. A serious outbreak of the disease, however, was observed in 1932 in the greenhouse of Trinidad Agricultural School. It is characterized by the powdery white appearance of the sur-

face of the leaves. The affected leaves usually wilt and dry up, and plants infected with powdery mildew are commonly stunted.

The root knot (*Heterodera radicicola*) was found on a few plants in Trinidad Agricultural School and also in Camp 7, Baguio, Mountain Province. This disease is characterized by the swelling of the roots, and the stunting and yellowing of the plants. Because of the more favorable conditions, the disease may eventually become more serious in the glasshouses than in the field.

Stem rot (*Sclerotium rolfsii*), or southern blight, is a minor disease of tomato in Trinidad Valley. It attacks the stem, causing it to rot, and finally the plant wilts and dies. Beans, potatoes, and larkspur are other crops found to be infected by this fungus.

*Fruit rots.*—Rotting of tomato fruits in the field or in storage is due either to *Phytophthora infestans, Sclerotium rolfsii, Bacteria, Fusarium, Macrosporium,* or *Rhizopus. Phytophthora infestans* is the most serious, causing under adverse conditions from 50 to 80 per cent or more infection of fruits in the field. Such fruits are no longer salable (Plate 14, figs. 1 and 2). The rot due to *Phytophthora infestans* is usually firm, but may become soft and watery as a result of invasion by soft rotting organisms. Sclerotium rot (*Sclerotium rolfsii*) is usually found on fruits lying on or close to the ground, but it is not a serious disease (Plate 14, fig. 3). The other fruit rots due to *Bacteria, Fusarium, Macrosporium,* and *Rhizopus,* of minor importance, are occasionally found in the field or in storage at room temperature.

The early blight (*Alternaria solani*) is a minor disease of tomato found in May, 1932, in Guisad, where older leaves close to the ground were most severely attacked.

## DISEASES OF UMBELLIFEROUS CROP PLANTS

Among the umbelliferous crop plants, carrots and celery are the two important crops grown commercially in these regions. Their culture, however, is not as extensive and general as that of cabbage, wongbok, beans, and peas.

### DISEASES OF THE CARROT

The carrot is a common crop in Trinidad Valley. The leaf blight (*Macrosporium carotæ* E. and E.) is the most serious disease found on the carrot. It causes spotting and blighting of the leaves so that the whole top may be completely blighted or blackened (Plate 15, figs. 1 and 2). It is much more serious

during the early and late seasons when the weather is warm and rains are frequent. During the dry season, from December to April, the disease is less severe so that a good crop may be obtained without the use of protective sprays.

### DISEASES OF CELERY

Celery is generally grown, but the presence of certain maladies often discourages farmers from planting it on a large scale. The diseases found are the late blight [*Septoria apii* (Br. and Cav.) Rostrup], black-heart (physiological), soft rot (*Erwinia carotovora*), root knot [*Heterodera radicicola* (Greef) Muller], dwarf (virus), and yellows (virus).

The late blight (*Septoria apii*) is a serious and widespread disease of celery in Trinidad Valley and the environs of Baguio. It is present all the year around in the greenhouse or in the field, but it is more serious during the early and late season, when the weather is warm and moist, severely blighting or spotting the leaves and leaf stalks (Plates 16 and 17). Plants severely infected are stunted and dwarfed so that they become unmarketable. The small spot type of late blight appeared to be the most prevalent and serious in this region and is recognized by the appearance of small irregular spots which are studded with numerous black fruiting bodies (pycnidia) of the fungus (Plates 16 and 17). The blanching method often employed in these regions, where plants are inclosed in wooden boxes or the stems covered with grass, is conducive to late blight infection. The American Self Blanching and the White Plume are the common varieties grown, and both are very susceptible.

Black heart (physiological) is common and rather serious on late plantings. In May, 1932, 100 per cent infection was found on celery plants growing at the farm of Trinidad Agricultural School. The disease may cause only slight tipburn on one or more of the inner younger heart leaves, but in the worst cases the entire heart is killed and turns black (Plate 18). Because of invasion of secondary organisms, the "diseased heart" may be completely rotted.

*Soft rot* (*Erwinia carotovora*).—A complete rotting of the "heart" without the intervention of the black-heart disease was also noted to be serious on celery. This is caused by the invasion of a bacterium, *Erwinia carotovora*. This disease is most active late in the season when the weather is warm and rains are frequent. Where straw and grass are used for blanching,

soft rot is more prevalent. Slugs, which are more abundant under these conditions, aid in spreading the soft-rot organism.

The root-knot nematode (*Heterodera radicicola*) was found on celery plants in glasshouse seed beds in Camp 7, Baguio. It was not as serious in the field as it is in seed beds under glasshouses. This disease is characterized by the swelling of the roots, yellowing of the leaves, and stunting of the plants.

Dwarf (virus) and mosaic (virus) diseases were found in 1930 in the Japanese Bazaar garden in Trinidad Valley. The dwarf disease causes dwarfing of the plant. The stalks are very much shortened and crowded and the plants are greatly stunted (Plate 19). Besides exhibiting some of the above symptoms, the mosaic disease is characterized by the mottling, clearing, or puckering of the leaves. These two virus diseases are of minor importance on celery.

## DISEASES OF MISCELLANEOUS CROP PLANTS

### DISEASES OF THE BEET

The beet is generally grown for leaves and for the root. The common leaf spot (*Cercospora beticola* Sacc.) and root canker (*Rhizoctonia* spp. or *Fusarium* spp?) are the two important diseases of the beet plant.

The leaf spot (*Cercospora beticola*) is very widespread in the field and in the greenhouse, causing 100 per cent infection. During warm and moist weather, especially in the early and late parts of the season, considerable spotting and rotting of the leaves are noted. When the weather is dry, the progress of the disease is checked; the infected tissues dry up and drop off, badly perforating the leaves. The disease is present the year around, but less serious during the dry season, so that a good crop may be harvested without the use of sprays.

Root canker (*Rhizoctonia* spp. and *Fusarium* spp.?) on beets was observed to be serious in 1930 at Trinidad Agricultural School, badly cracking or corroding 25 to 75 per cent of the crop (Plate 20), making it less salable. The disease is most prevalent on beets planted in December or January and harvested during the warmer months. Infected plants are usually dwarfed, and the petioles of the young leaves turn black and finally die. The first sign of the disease on the fleshy tap root is slight browning or blackening of the affected region, while in the more-advanced stages cracking or corroding of a greater portion of the tissues may be observed. Isolations made from the fresh or advanced lesions showed that species of both *Rhizoctonia*

and *Fusarium* are associated with the malady. Thus far, however, no test has been made to show which of these organisms is the real cause of the trouble.

DISEASES OF CORN

Philippine native corn and American sweet corn are usually cultivated as a garden crop during March, April, and May. Corn rust (*Puccinia sorghi* Schw.) is a disease very commonly observed in Trinidad Valley but not in the corn-growing regions in the lowland provinces. It was also observed in 1930 on a farm in Lilio, Laguna Province, Luzon, at the foot of Mount Banahao, where the climate is relatively cool and moist. The disease is recognized by rust pustules on the leaves and leaf sheaths containing orange yellow powdery-spore masses. When plants are infected early and numerous rust pustules are developed, part or all of the leaves dry up and as a result the plants are dwarfed. Both native corn and American sweet corn grown in Trinidad Valley were found to be very susceptible to the disease.

DISEASES OF LETTUCE

Both leaf lettuce and head lettuce are grown in these regions. The important diseases noted on them are leaf spot (*Cercospora lactucæ* Stevenson), soft rot (*Erwinia carotovora*), and tipburn (physiological trouble).

Leaf spot (*Cercospora lactucæ*) is a common disease late in the season, especially severely affecting the flowering lettuce plants. The spots are brown, round to irregular in shape, and characterized by a dead gray center which is surrounded by a light brown infected area. It is most serious during the warm moist weather of May, June, and July, when 25 to 100 per cent of the leaves may be badly spotted. This disease is also found to be serious on lettuce in the gardens around Manila.

Tipburn, a physiological trouble in which excessive water and rapid evaporation may be associated, was found to be serious on lettuce grown on the reclaimed plots in the swamp in Trinidad Valley. A certain variety with yellowish, pale, thin leaves showed 100 per cent tipburn, while the "Los Angeles," a dark green thick-leaf variety, showed less than 10 per cent infection. The trouble is commonest during April and the early part of May when the weather is usually warm and dry. The symptoms are limited to "burning" of the edges and tips of the leaves (Plate 21), but because of secondary invasion of other organisms the infected parts rotted rapidly.

The soft rot (*Erwinia carotovora*) is also found on this plant but is not a serious trouble of lettuce in these regions.

### DISEASES OF OATS, WHEAT, AND BARLEY

Temperate-zone cereal crops such as oats, wheat, and barley have been found to grow successfully in the Mountain Province. In Trinidad Valley, wheat and barley were found growing well and free from serious diseases. The loose smut [*Ustilago avenæ* (Pers.) Jens.] was found at Haight's Place, Mountain Province, where five panicles from a small plot planted with oats showed smut infection. The disease manifests itself by the complete transformation of grains into black powdery masses which are the spores of the fungus (Plate 22). The causal organism is known to be carried with the seed, and no doubt its first occurrence in Haight's Place is due to the presence of contaminated seeds in the lot. From information it was found that the seeds were obtained from England the year before, and no doubt the disease has been introduced.

### DISEASES OF THE ONION

The onion is grown more extensively in Trinidad Valley for its top than for the dried onion bulb. A leaf blight of the green onion caused by *Macrosporium porri* Ellis has been found to be most serious, causing 100 per cent infection in the field. Under favorable environmental conditions of warmth and moisture the disease causes complete blighting of the leaves (Plates 23 and 24). The white Bermuda onion and the Chinese green onion are both susceptible. Garlic, "kutchay," and other members of this family, which are grown for their tops but on a very small scale, have not been found to be affected by the disease.

### DISEASES OF RHUBARB

Rhubarb is still grown on small plots, but it is becoming more popular among the Chinese and Japanese farmers. The rhubarb rust [*Puccinia phragmitis* (Schum.) Korn.] has been found in Trinidad Valley and at Haight's Place, Mountain Province. The disease is usually severe on the lower leaves. The spots are small, but when they coalesce bigger spots are formed. The disease is seldom serious.

### DISEASES OF THE STRAWBERRY

The strawberry constitutes a favorite crop among the native farmers in Trinidad Valley and other localities near Baguio. It is not, however, as extensively cultivated as the cabbage. The

diseases found on the strawberry are leaf spot [*Mycosphærella fragariæ* (Schw.) Lind.], fruit rot (*Rhizopus nigricans* Erh.), dwarf (virus), and yellows (virus).

*Leaf spot* (*Mycosphærella fragariæ*).—This disease appears to be common and is generally found on nearly all strawberry plots in Baguio, in Trinidad Valley, and, at Haight's Place, Mountain Province. In certain cases the spots are so numerous as to cause considerable "shot-holes" and thus to stunt the plants (Plate 25). All the common commercial varieties and the native ones grown in these regions are susceptible to the disease.

*Fruit rot.*—The black mold (*Rhizopus nigricans*) is a common fungus, causing considerable rotting of strawberry fruits in the field but especially in storage and transit. This disease is recognized as a soft watery rot, but in advanced stages the infected fruit may be completely rotted and mushy, and covered by the mycelia and black fruiting bodies of the fungus (Plate 26). Shipment of strawberries from Baguio to Manila markets and storage without refrigeration often result in a loss of 30 to 50 per cent or more due to this fruit rot. The fungus is favored by warm temperature (room temperature), and because of improper handling and lack of refrigeration the disease, once started, progresses so rapidly that a basketful of strawberries may be completely ruined in one or two days (Plate 26).

Strawberry dwarf, strawberry yellows (virus diseases), and stem canker (*Rhizoctonia*) are other less important diseases of the strawberry.

## GENERAL DISCUSSION

By no means all diseases on the various crops in Trinidad Valley and the vicinity of Baguio, Mountain Province, are here reported. Others may have been present when the surveys were made. A few of these diseases are tropical, but many of them are representatively semitemperate or temperate in habitat, probably of foreign origin, introduced (with seeds, vegetative parts, etc.) recently or some years ago and here reported for the first time in this part of the Philippines. Some of them are now limiting the culture of certain crops, and even those that at present are of minor importance may in a few years become formidable obstacles to successful farming in these localities. Some of these diseases, such as the late blight of potato and tomato, late blight of celery, the leaf spot of "wongbok" and pechay, the angular leaf spot of beans, the bean rust, the asco-

chyta leaf blight of peas, the black leg of cabbage, and the soft rot of cabbage and other vegetables, are now serious and important, whereas a few years ago they were perhaps not of much consequence. Because of the ideal environment for the multiplication and the rapid spread of the organisms, the diseases found on the various crops are bound to increase and become a serious factor in these regions.

So far no detailed studies have been conducted for the purpose of controlling these diseases. Practical Japanese and Chinese farmers of Trinidad Valley and student farmers of Trinidad Agricultural School are making every effort to control some of them, but due to ignorance of the fundamental behavior of the diseases their experiences in most cases are costly and their results discouraging. Since conditions in the Philippines are different from those in other countries where the diseases have been studied, it will be necessary, before any intelligent, efficient, and specific control measures can be suggested for any particular disease, that information on the fundamental biological behavior of the organism and the epidemiology of the disease as it occurs in the Philippines be known. Knowledge of the biology of the host and information based on experiments in the use of protective sprays or dusts, and selection or breeding for resistance, should likewise be studied. Knowledge along these lines may eventually lead to change of farming practices in these regions.

Since the diseases listed above are caused by specific organisms and require specific control measures, and since effective control measures are usually based on experiments made under local conditions, what is effective in checking the disease elsewhere might prove useless under Philippine conditions. As time has not yet permitted the writer to study each of these diseases in detail, the following remedial and general control measures, if followed, may be of value, especially to the farmers in these localities.

*Sanitation.*—Most garden-crop diseases are either first introduced into the field with seeds, infected seedlings, or plant propagative parts, or brought in with the soil or with the wind. If the field conditions are favorable, the pathogenic organisms multiply rapidly and spread to various parts of the field by various agencies, such as insects, wind, water, contaminated soil clinging to the farm implements, hoofs of animals, feet of men, etc. Therefore, it is necessary to destroy by burning all infected plants and their parts found in the field or seedbed. Since

these serve as a source of infection to neighboring plants, the field should be kept free from all rubbish.

*Healthy seeds.*—Only seeds from healthy plants or seeds that are known to be free from diseases should be used. The seeds should be raised locally if practicable, or else purchased from reliable sources. Newly opened land or farms in isolated places should be protected from contamination with diseases brought in with seeds, seedlings, and other propagating stocks, or with contaminated soil.

*Disinfection of seeds.*—As diseases are carried on or in the seed, sterilizing the seeds with disinfectant is necessary. Mercuric chloride (1:1000) or formalin (40 per cent formaldehyde), diluted in water in the proportion of 1 pint to 30 gallons of water, is generally used as a disinfecting agent. The length of time for treatment depends upon the kind of seeds and the chemical used. Generally, small-seeded garden crops are sterilized after treatment of three to fifteen minutes, and for potato tubers one to two hours may be sufficient. For diseases carried internally by the seed or by the tubers, hot-water treatment, aging the seed for a few years, or the "index method" for tubers may be used.

*Care of seed bed and seedlings.*—The seed bed should be kept free from diseases. Young plants are subject to many diseases, and since they are important sources of infection, the seedlings transplanted to the field must be healthy. Neither care nor expense should be spared to protect them in the seed bed, whether one uses dusts or suitable sprays. The bed could be made free from diseases by sterilizing the soil with direct heat, steam, or chemicals, and if this is not possible, fresh soil should be used.

*Spraying and dusting.*—The use of sprays and dusts is one of the direct methods of control, but it is only temporary and its effectiveness largely depends upon thoroughness and frequency of application. It has for its purpose the protection of the plants with substances harmless to them and at the same time poisonous to the parasites. Standard Bordeaux mixture (4–4–50), Burgundy mixture, lime sulphur, flowers of sulphur, and copper-lime dust are some of the common sprays and dusts generally used to protect plants from diseases. The strength of the spray concentration or amount of dust applied or the frequency of their application depends upon the host plant and the disease under consideration.

*Crop rotation.*—Crop rotation is not only essential to the control of disease, but also beneficial to the maintenance of soil

fertility. The object of crop rotation as a means of control is to starve the parasites by changing the cultivation of a susceptible to that of a resistant host plant for two or more years. Plants of related species having diseases in common should not be planted in the same piece of ground continuously, or interplanted at the same season.

*Resistant varieties.*—The use of resistant varieties is the most profitable and most important phase in plant-disease control. The task of securing resistant or immune varieties is a long and arduous, but not an impossible one. There are crops now in cultivation that are resistant to certain serious diseases, which were developed by patient, continuous selection and breeding.

The selection and development of resistant varieties, however, has its limitations and cannot solve all difficulties. There are diseases against which resistance cannot be developed, and in such cases other means of control, such as spraying, dusting, and other methods mentioned above, should be used. Furthermore, one should bear in mind that in most cases resistance is specific to certain diseases only; it is local—that is, a plant may be immune in one locality and highly susceptible in another; and resistance in a certain crop may be temporary, and may disappear in the course of time. The variation or loss of resistance in such plants is not only due to the fact that plants vary in resistance to their parasites, but the parasites themselves vary in their ability to attack their host plants. Within these limitations the continued selection for resistance to disease and the use of resistant varieties when available and possible should therefore be encouraged, and once resistant crops have been obtained, they should be kept in pure line.

# ILLUSTRATIONS

PLATE 1

Stems of cabbage plants infected by black leg (*Phoma lingam*). The extent of the injury, which caused the death of the plant, is shown. The pycnidia of the fungus may be seen at X. The plants died before the head was well developed.

PLATE 2

FIG. 1. A cabbage leaf taken from the lower old leaves of a plant infected with black leg.
2. Black rot on a cabbage leaf. The blackening of the veins advancing inward from the edge of the leaf, which is characteristic of the disease, is shown.
3. Leaf spot on a cabbage leaf. The lesions are circular to irregular spots, generally light brown to dark brown, with concentric rings.
4. A cabbage head infected with soft rot in the field and now showing an advanced stage of the disease. The central core is completely rotten and massy, emitting a foul odor.

PLATE 3

Chinese cabbage "wongbok" leaf, showing spots caused by *Alternaria herculea*. This leaf was taken from one of the other leaves of the formed head and is severely spotted.

PLATE 4

FIG. 1. Leaf spot of cauliflower, due to *Alternaria brassicæ*.
2. Head rot of cauliflower, due to *Altenaria brassicæ*.

PLATE 5

FIG. 1. Leaf spot of pechay, due to *Cercospora brassicicola*.
2. Leaf spot of pechay, due to *Alternaria* species, perhaps *Alternaria brassicæ*.

PLATE 6

Typical leaf spot of turnip, due to *Alternaria herculea*.

PLATE 7

FIG. 1. Angular leaf spot of garden bean, due to *Isariopsis griseola;* typical symptoms.
2. Mosaic (virus) of garden bean; typical symptoms.

PLATE 8

FIG. 1. Pustules of bean rust on a bean leaf.
2. Typical anthracnose spots on bean pods.

PLATE 9

Pea plants badly infected by ascochyta leaf blight. Most of the leaves on the lower portion of the stem are killed. The leaves and stem show typical lesions. Young plants severely affected are generally killed by this disease.

PLATE 10

A potato field infected with late blight disease. This field later became ruined.

PLATE 11

FIG. 1. Section of a healthy potato tuber.
2. Section of a potato tuber infected with potato blight, *Phytophthora infestans*. The characteristic browning and blackening of the tissues are shown.
3. Potato tubers infected with *Rhizoctonia*. The sclerotia of the fungus are seen adhering to the tuber.
4. A potato tuber showing typical scab lesions.
5. A healthy potato tuber.

PLATE 12

A portion of a tomato plot showing a tomato plant badly infected with late blight, *Phytophthora infestans*. Nearly all the aërial parts of the plant, including the fruits, showed infection. This plant died within a few days and failed to bear fruits.

PLATE 13

FIG. 1. Tomato leaves showing mosaic (virus) symptoms.
2. Tomato leaves showing fern leaf (virus) symptoms.

PLATE 14

FIG. 1. Fruit rot of tomato due to a late-blight organism. This fruit was later secondarily infected by a species of *Fusarium* (the white mass of mycelia), which caused complete rotting.
2. Section of a tomato fruit infected by late blight. The extensive browning of the tissues on the affected region, which is firm, is characteristic of the disease.
3. A tomato fruit infected by *Sclerotium rolfsii*. Young sclerotial bodies are formed on the infected region. Fruits close to the ground or lying on it are generally attacked by this fungus.

PLATE 15

FIG. 1. A carrot plant severely attacked by leaf blight (*Macrosporium carotæ*. The tops (leaves and petioles) are all killed or blighted. About × 0.5.
2. A dried carrot leaf; the condition is due to leaf blight. About × 2.

PLATE 16

Typical spots on the leaves and stem of celery badly infected by late blight, *Septoria apii*. The small spot type of late blight is more prevalent in this region.

PLATE 17

A "bleached" celery plant badly attacked by late blight, showing infection on the stems and the leaves. The outer and older leaves, because of the severe infection, are dried up. Only the few young leaves of the "heart" did not show infection.

PLATE 18

A celery plant infected with "black heart" disease. The entire heart of the plant turned black and died. Complete rotting of the "heart" may follow due to invasion of secondary organisms.

PLATE 19

A celery plant showing the typical symptoms of dwarf disease (virus). The crowding and shortening of the petioles of the infected plant are characteristic.

PLATE 20

Typical symptoms of dry rót on the beet. The corroded or cracked regions are characteristics results of the disease. A species of *Rhizoctonia* and a species of *Fusarium* are usually isolated from the lesions.

PLATE 21

FIG. 1. A lettuce leaf with dried or killed tip, due to tipburn.
2. A lettuce plant infected with tipburn. Some affected leaves can be readily recognized.
3. A lettuce leaf showing the typical spots due to *Cercospora lactucæ.*

PLATE 22

FIG. 1. A healthy oat panicle.
2. Oat panicle infected with loose smut. The grains are transformed into powdery black masses. These are the spores of the fungus.

PLATE 23

FIG. 1. Onion plants with dried infected leaves due to the leaf-blight disease (*Macrosporium porri*). About $\times$ 0.5.
2. An onion leaf showing the typical oval or irregular-shaped lesions. The black tufts in the lesions at X are the fruiting structures of the fungus.

PLATE 24

FIG. 1. A strawberry plant infected with the leaf-spot disease.
2. Typical lesions of the disease on the strawberry leaf.

PLATE 25

FIG. 1. A basket of healthy strawberry fruits, as marketed in Baguio.
2. A basket of strawberries completely ruined by common black mold (*Rhizopus nigricans*) after seventy-two hours at room temperature in the laboratory in Trinidad Agricultural School. The mycelia and the black fruiting bodies of the fungus may be seen covering the rotten fruit.

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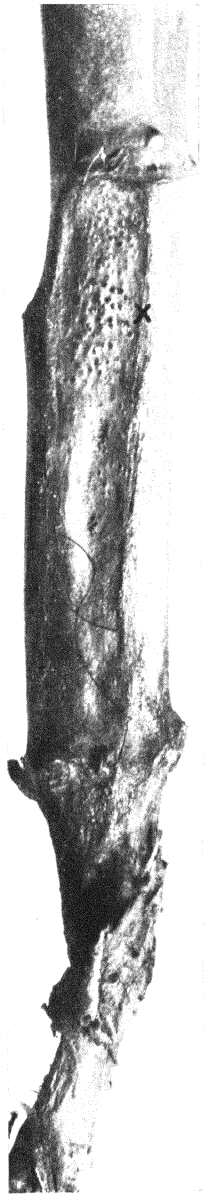

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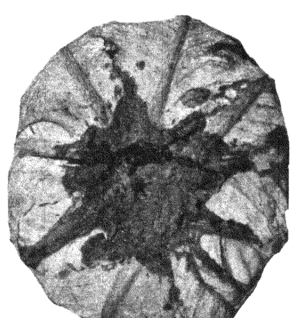

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PLATE 2.

PLATE 3.

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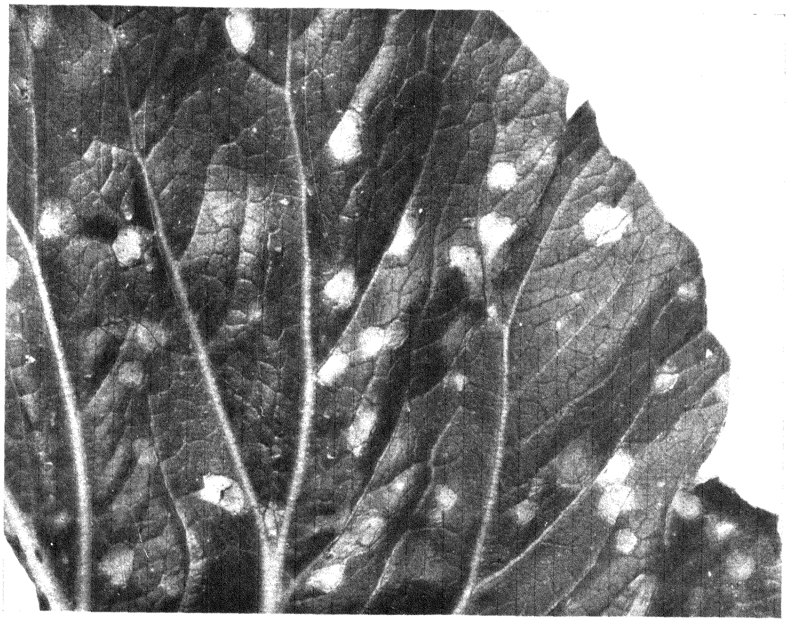
PLATE 4.



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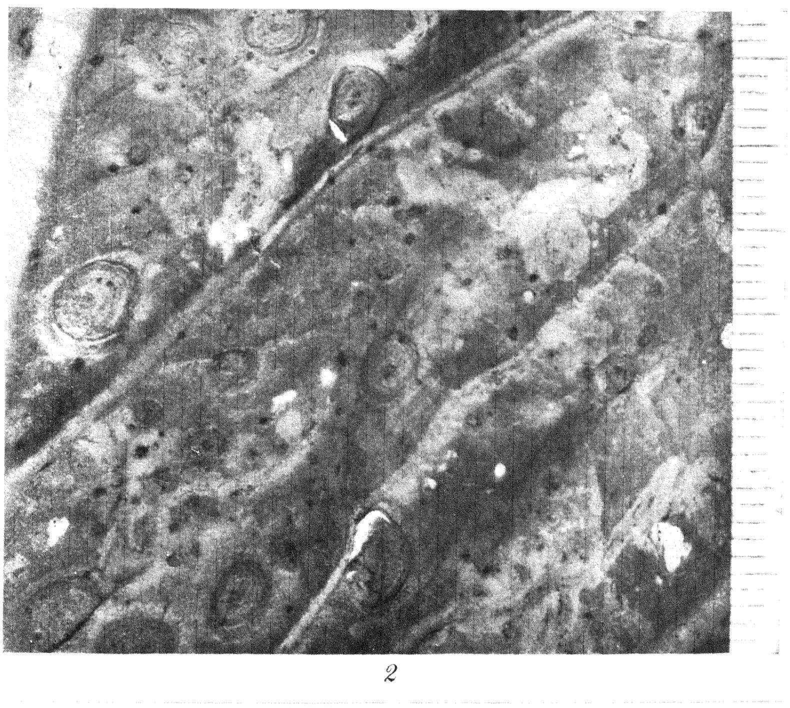

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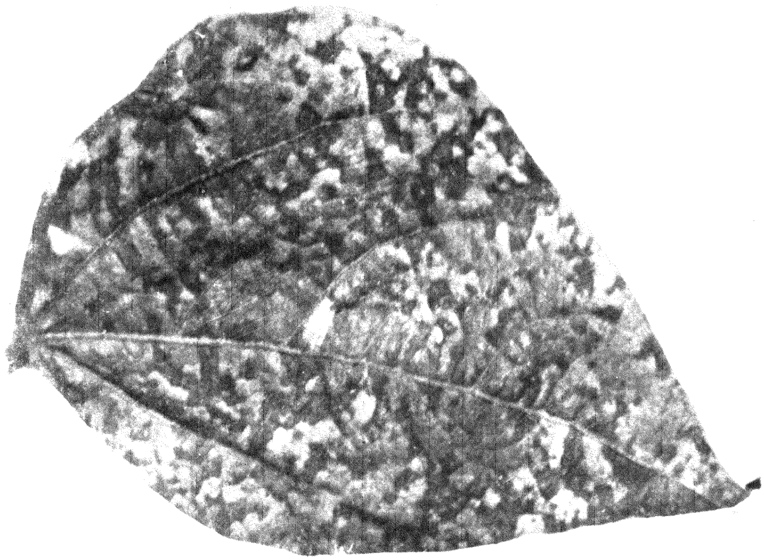
PLATE 5.

PLATE 6.



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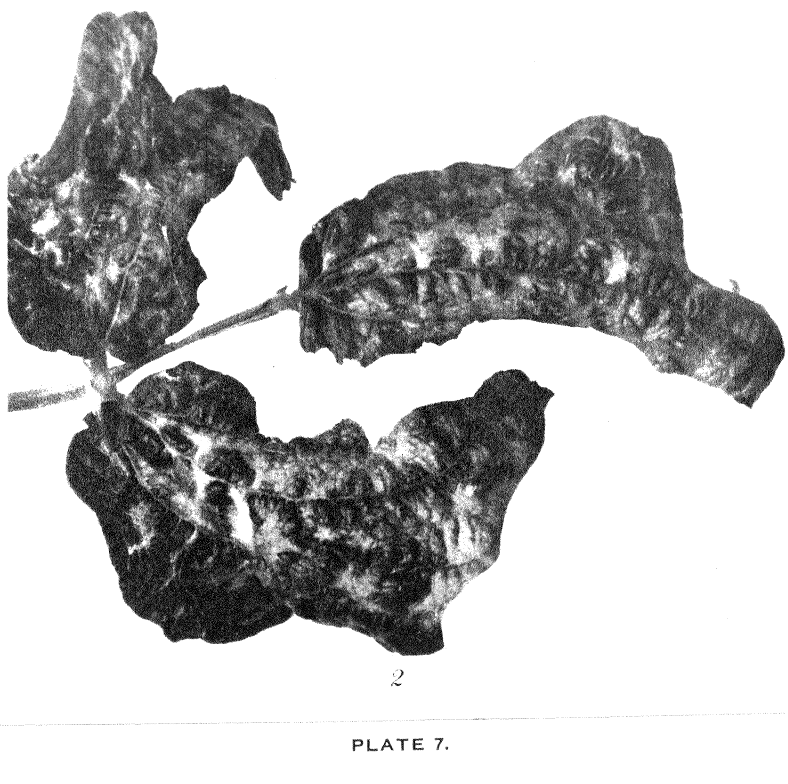

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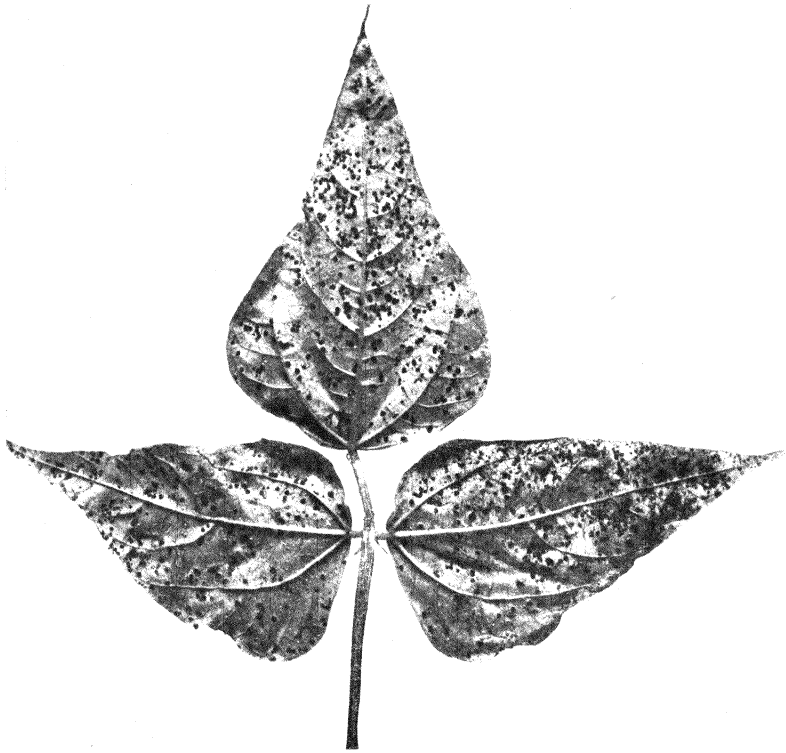
PLATE 7.



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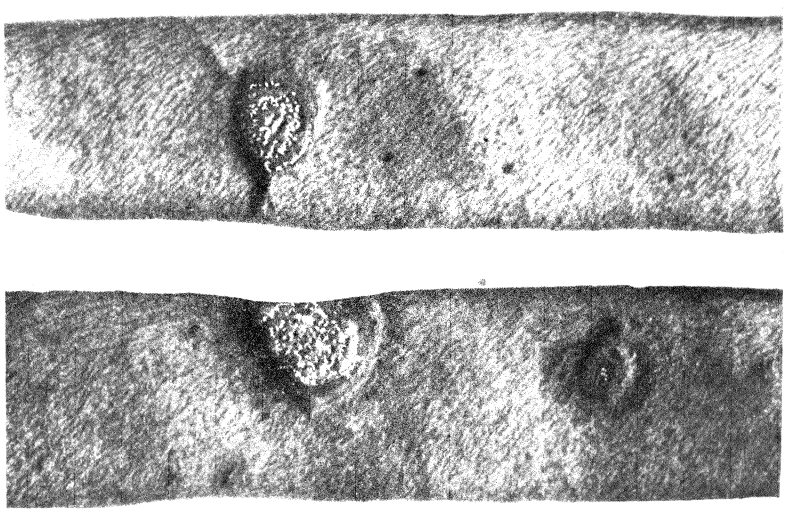

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PLATE 8.

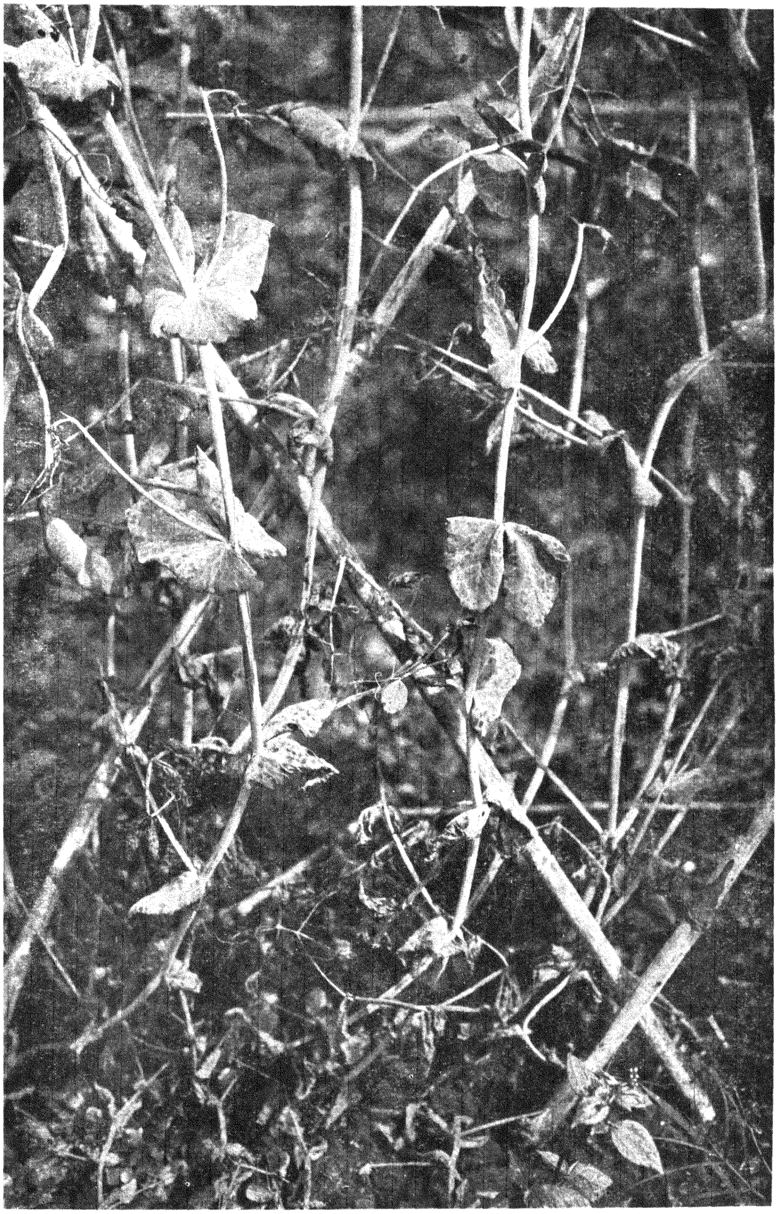


PLATE 9.

PLATE 10.


PLATE 11.

PLATE 12.

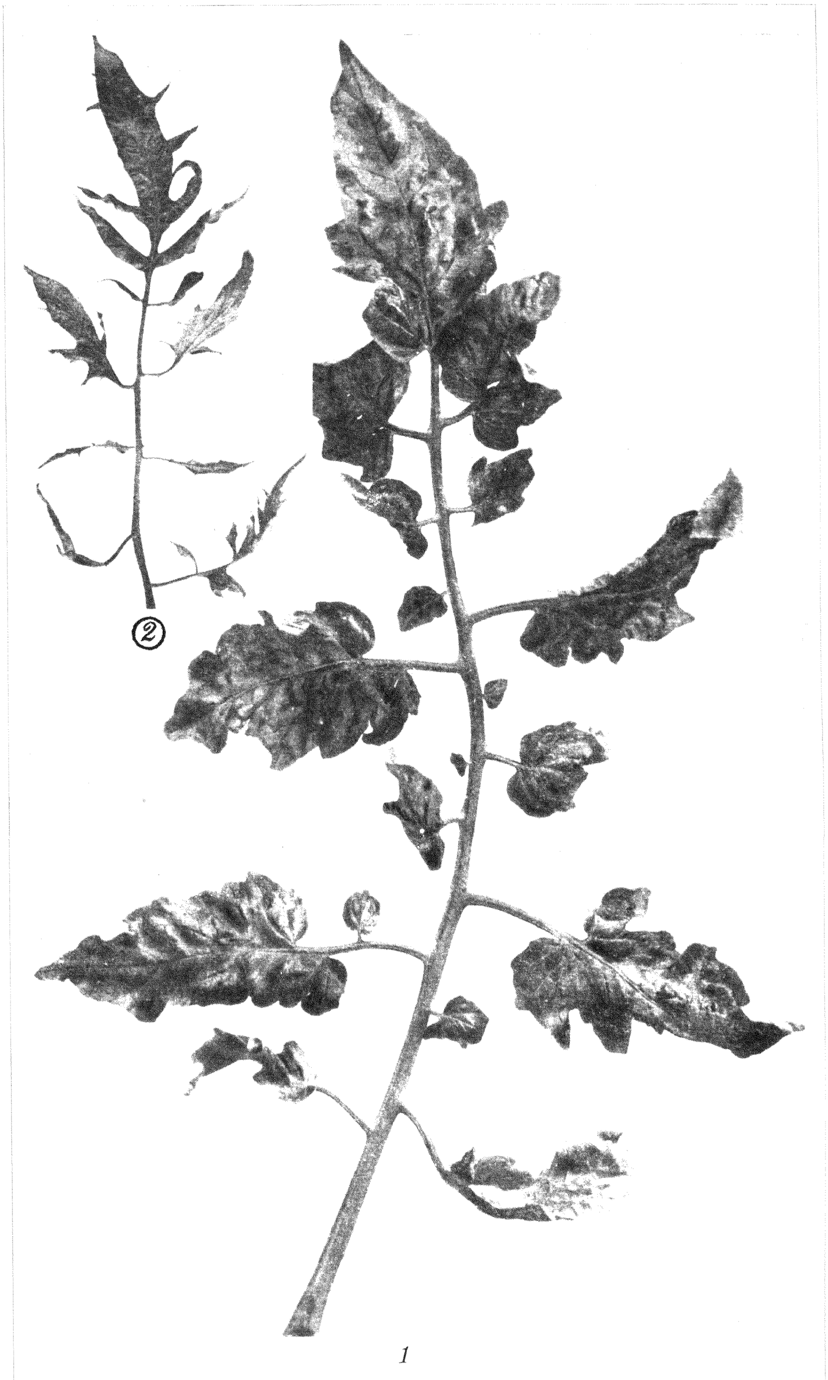
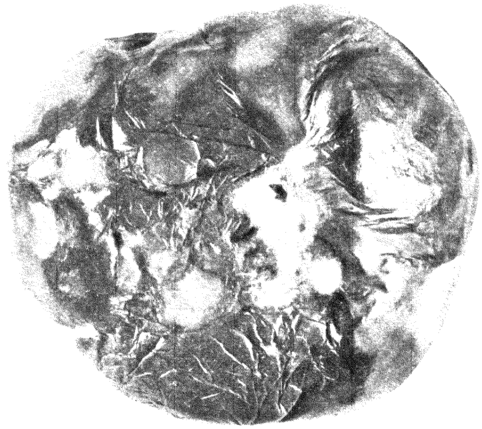



PLATE 13.



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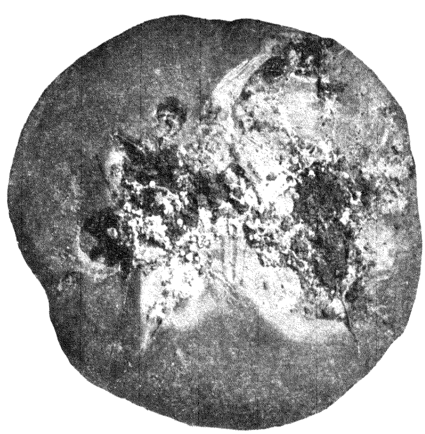

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PLATE 14.

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PLATE 15.

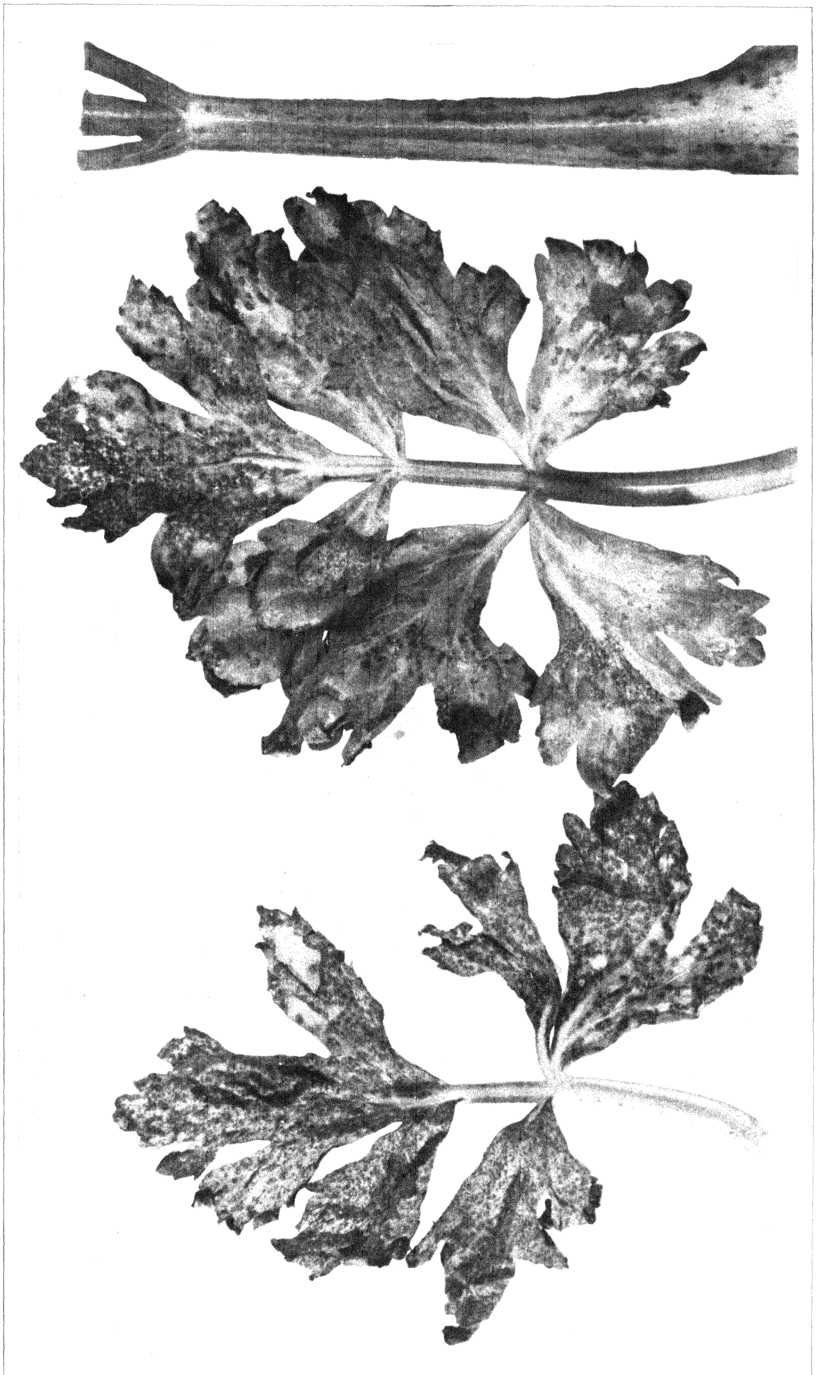

PLATE 16.

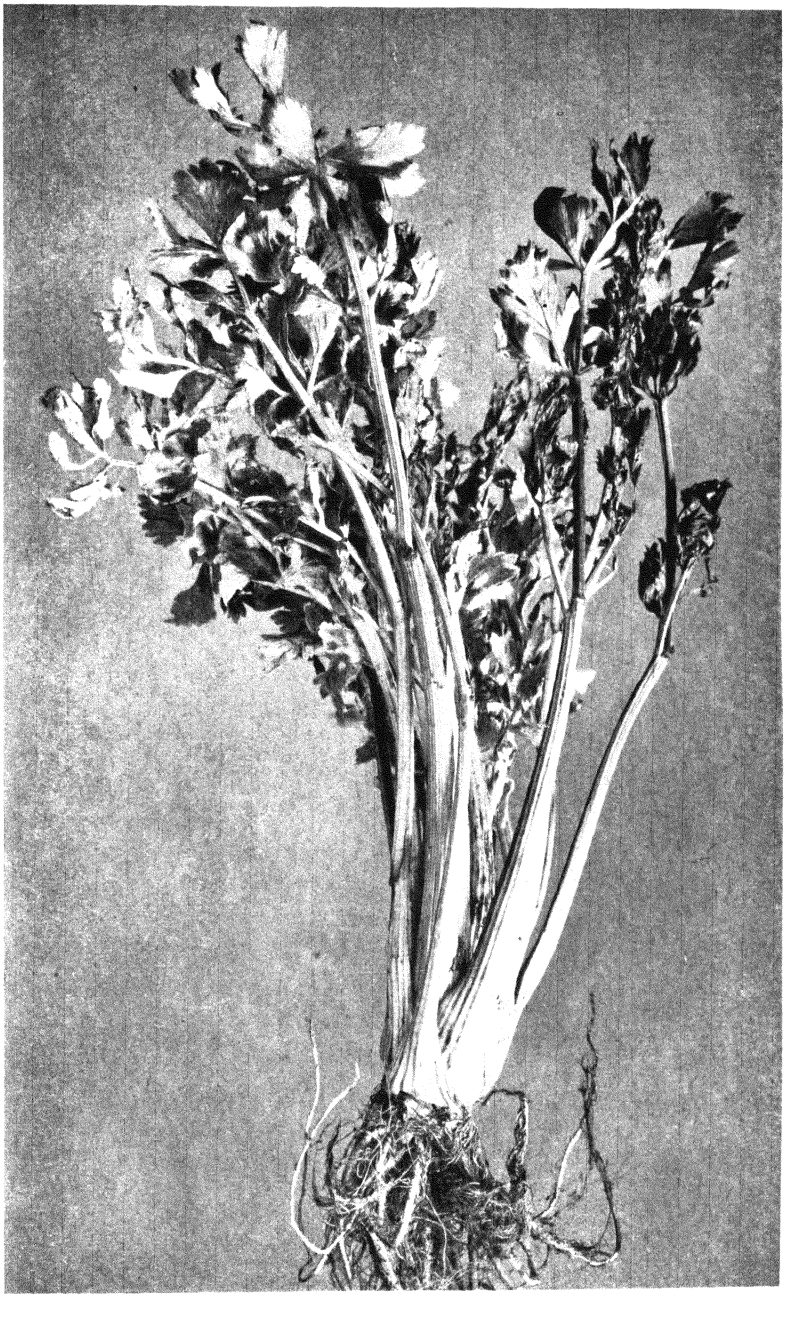

PLATE 17.

PLATE 18.

PLATE 19.

PLATE 20.

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PLATE 21.

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PLATE 22.


PLATE 23.

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PLATE 24.

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PLATE 25.

# STUDIES IN SURRA, I

## THE BLOOD CHEMISTRY IN EQUINE TRYPANOSOMIASIS (TRYPANOSOMA EVANSI)[1]

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The manner in which pathogenic trypanosomes produce death in their hosts has been a subject of considerable controversy. One method of approach in an attempt to solve the problem, which has been utilized by many workers, is by the study of the alterations of the blood chemistry in experimental trypanosomiasis.

Opposing views on the lethal factors in death from trypanosomiasis have been set forth as follows: First, that the injury and ultimate death of the host are due to a toxic substance liberated by the disintegration of the parasites, as proposed by Regendanz and Tropp (1927) and others; second, that the cause of injury and ultimate death of the host is the exhaustion of the blood sugar and glycogen reserve, as held by Schern (1925–28) and von Fenyvessy (1926); third, in rats at least, Andrews, Johnson, and Dormal (1930) believe that death of the host is due to asphyxia brought about by pulmonary œdema due to partial obstruction of the circulation by the agglutination of the trypanosomes in the heart and lungs.

Regendanz and Tropp, who support the toxin theory, were unable to confirm the findings of Schern and von Fenyvessy in regard to the exhaustion of blood sugar and glycogen reserve. Their results indicate that the glycogen depletion is by no means complete and at the height of the infection sufficient glycogen remains in the liver to maintain a normal sugar concentration in the blood. They maintain that the decrease in the blood sugar is due to a depressive effect on sugar inversion by the trypanosome toxin and not the depletion of glycogen.

[1] This paper was read in part before the Fifteenth Annual Meeting of the Philippine Veterinary Medical Association February 11, 1933, and the completed manuscript submitted for publication October, 1933.

Kligler, Geiger, and Comaroff (1929), investigating von Fenyvessy's toxin theory, injected massive doses of autolyzed trypanosomes and plasma respectively from guinea pigs heavily infected with various pathogenic trypanosomes into rabbits and rats, the animals receiving from seven to ten injections in the course of two weeks. In the rabbits the injection of autolyzed trypanosomes and, to some extent, the injection of plasma alone produced a leucopenia. As no other toxic manifestation was observed in either the rats or rabbits, they conclude that the repeated injection of heavy doses of autolyzed trypanosomes did not exert an appreciable toxic effect on the animals. The effect produced, as shown by the leucopenia, is not sufficient to account for the severe damage and ultimate death caused by the infection on the basis of a toxæmia. These workers also made quantitative determinations of the lactic acid in the blood and of the oxygen consumption of rats infected with *Trypanosoma evansi*. They did not find a higher oxygen consumption in infected rats and assume that incompletely oxidized metabolic products of glucose from the activity of the trypanosomes produce a state of acidosis in the animal, leading to exhaustion of the alkali reserve and probably also to a depression of the oxidative processes by the specific effect of lactic acid on the hæmoglobin. By supplementing the alkali reserve twice daily with 0.5 cc of 10 per cent sodium bicarbonate solution, intraperitoneally, they were able to prolong the life of a treated set of rats 50 per cent over that of an untreated set.

Scheff (1928, 1932) agrees that trypanosomes utilize large amounts of glucose and states that the glycogen reserve of the liver becomes exhausted. In guinea pigs, in which the course of infection is prolonged and undulating as compared to the rat, the resulting hypoglycæmia is apparently compensated as shown by a hyperlipemia. He describes in rats infected with *Trypanosoma equiperdum*, a form of internal asphyxia further embarrassing the liver, which is followed by an acidosis contributing to the metabolic disturbances leading to the death of the animal.

Andrews and his associates, using rats infected with *Trypanosoma equiperdum*, state that the animals die of asphyxia and on pathologic evidence, conclude that this is due to a retardation in the circulation of the blood due to agglutination of trypanosomes in the heart and lungs. The consequent anoxæmia leads to a nonvolatile uncompensated acidosis and to central necrosis of the liver, interfering with both its glycogenic and glycogenolytic functions and ultimately producing a hypoglycæmia.

That the mere presence of trypanosomes in a host produces acidosis appears to be disproved by the work of Linton (1930), who found that the nonpathogenic trypanosome, *Trypanosoma lewisi,* in contrast to pathogenic trypanosomes, can be present in the rat in great numbers and yet not produce an acidosis or lowering of the glycogen content of the liver.

The above-described experiments usually have been conducted with small laboratory animals, chiefly rats, an exception being the experiments of Tubangui and Yutuc (1931), who included horses in their studies on the resistance and the blood sugar of animals infected with *Trypanosoma evansi.* These workers conclude that no evidence was obtained to show that resistance against surra is dependent on the ability of the host animal to maintain a normal blood-sugar content. In the majority of their cases, which included rats, guinea pigs, cats, dogs, and horses, no appreciable changes in the sugar content of the blood was observed during the course of the infection except at the very end, when a terminal or agonal hypoglycæmia was usually detected. Their findings were in accord with those of Zotta and Radacovici (1929, *a, b*) who call this condition a premortal hypoglycæmia and state that it occurs not only in trypanosomiasis but also in several other diseases.

Wormall (1932), in determinations on the blood-sugar changes in human trypanosomiasis, found no general hypoglycæmia during the earlier stages of the disease, but at times found values significantly lower than the lowest value with a normal human. Treatment with Bayer 205 gave variable results in relation to the blood-sugar level; sometimes there was a fall, sometimes a rise, and in other cases no change in the blood-sugar level. The injection of 1 gram of Bayer 205 to a patient with the lowest blood-sugar value resulted in a speedy return to normal (or perhaps slightly high) values. He concludes that in glucose tolerance tests carried out on a few of the patients and some of the controls do not suggest that in trypanosomiasis there is a very marked impairment of the capacity of the liver to deal with glucose.

There is very little information available in regard to the blood chemistry changes in the natural hosts of *Trypanosoma evansi.* In the writer's experiments, one of the hosts, the horse, was used with a view to obtaining more information as to the lethal factors in *Trypanosoma evansi* infection (surra) with particular reference to those factors which manifest themselve by changes in the chemical constituents of the blood.

The animals were stabled in screened stalls at the Insular Veterinary Laboratories, Pandacan, Manila. The trypanosome used for inoculation was a strain of *Trypanosoma evansi* that had been isolated from a naturally infected horse by Dr. T. Topacio, of the same laboratories. To prevent an acute explosive type of infection, subcurative doses of Bayer 205 (naganol) were used in amounts that were successful in producing a chronic form of this disease.

The following blood chemistry determinations were made: The carbon dioxide capacity of the blood plasma, and milligrams per 100 cc of blood of nonprotein nitrogen, blood sugar, creatinin, lipoid phosphorus and calculated lecithin. Complete blood and trypanosome counts were also made. The blood was drawn from the jugular vein into flasks containing potassium oxalate and, in addition, neutral paraffin oil was added to the specimens to be used for the carbon dioxide determinations.

To test the theory that the disintegration of trypanosomes liberates a toxin, horse A was infected with *Trypanosoma evansi* and when its blood contained an average of 2,200 trypanosomes per cubic millimeter, it was given 3 grams of Bayer 205 (naganol) intravenously in 60 cc of distilled water. The blood chemistry findings in this horse previous to the administration of the drug were as follows: $CO_2$ combining power, 57; lipoid phosphorus, 11.40; calculated lecithin, 285; nonprotein nitrogen, 43.5; creatinin, 1.7; temperature, 39.9° C. At the time when the Bayer 205 was given breathing was labored and the animal showed marked ventral swelling and was in a state of clinical acidosis. Twenty-four hours after the administration of Bayer 205, an examination of concentrated portions of blood failed to reveal trypanosomes and inoculation into rats was negative. Clinical symptoms of acidosis were markedly improved and the temperature was 38.4° C. Forty-eight hours after, there was no evidence of clinical acidosis and the temperature had returned to normal. Seventy-two hours after the administration of Bayer 205, blood chemistry determinations showed the following: $CO_2$ combining power, 68; lipoid phosphorus, 8.30; calculated lecithin, 207; nonprotein nitrogen, 26.6; creatinin, 1.6; temperature and respirations normal. Although the temperature was elevated slightly the next day and remained so for four days, when it returned to normal, trypanosomes during this period could not be demonstrated. The ventral swelling had disappeared on the

fifth day. Had there been an endotoxin liberated by the disintegrating trypanosomes, this, together with the slight toxic action of the drug in an infected animal, should have produced more definite symptoms of a toxæmia. As the blood chemistry findings had returned to normal for the animal, there appears to be no evidence in this case that the death of a large number of trypanosomes in the blood circulation liberated an endotoxin detrimental to the animal.

An attempt was also made to determine the toxic effect of injecting into normal animals a suspension of livers and spleens, rich in trypanosomes, that had been obtained from rats in the terminal stages of trypanosomiasis. Rats were infected with *Trypanosoma evansi* and when in the terminal stages of infection were destroyed. Immediately the organs were removed, weighed, then ground to a fine pulp and suspended in twice their weight of sterile physiological salt solution, with the addition of 1 per cent chloroform for a preservative and to kill the trypanosomes. Two normal horses were given this suspension subcutaneously in three doses at four-day intervals in the following amounts: 3 cc, 5 cc, and 10 cc. Other than local swelling that subsided in the interim, there was no clinical evidence of a toxic condition being produced by these injections. The injections made the animals hypersensitive to a later inoculation of live trypanosomes, as was shown by a shorter incubation period, as compared to other animals not so treated.

Primarily to determine if death is due to an exhaustion of blood sugar and to measure the amount of blood sugar present during the infection and at time of death, horses B and C were inoculated with *Trypanosoma evansi.* Results of blood chemistry and blood picture findings during the course of the disease are given in Table 1. By the use of small doses of Bayer 205 (naganol) the disease ran a chronic course in both animals with many crises and relapses. As the infection progressed a marked anæmia developed. Acidosis was more marked at the time of crises at which times the animals had a lower blood-sugar content, with a higher content of lipoid phosphorus, calculated lecithin, nonprotein nitrogen, and creatinin. Shortly following these crises, the $CO_2$ combining power of the plasma increased, but never returned to normal, and the lipoid phosphorus, calculated lecithin, nonprotein nitrogen, and creatinin showed a decrease. The blood-sugar level usually rose after a crisis and was at times higher than normal.

The average weight of the horses at time of inoculation was 1,000 pounds. Horse B lived for seventy days and horse C lived for forty-four days after inoculation, and the weight of each of the animals had decreased approximately 25 per cent at the time of death.

TABLE 1.—*Blood changes in horses infected with Trypanosoma evansi.*

| Period of infection. | Volume per cent. Carbon dioxide capacity. | Milligrams per 100 cc of blood. Lipoid phosphorus. | Lecithin. | Nonprotein nitrogen. | Creatinin. | Sugar. | Number per ccm of blood. Red blood cells. Millions. | White blood cells. Thousands. | Trypanosomes. Thousands. |
|---|---|---|---|---|---|---|---|---|---|
| HORSE B. | | | | | | | | | |
| Before infection | 70.0 | 8.5 | 212 | 25.5 | 1.5 | 85 | 6.9 | 6.5 | 0 |
| Thirty-five days after infection. | 52.3 | 11.8 | 295 | 33.3 | 1.8 | 87 | 3.8 | 10.5 | 45 |
| Forty-eight hours prior to death. | 45.8 | 13.3 | 332 | 50.0 | 1.8 | 72 | 3.9 | 7.7 | 20 |
| Twenty-four hours prior to death. | 30.0 | 14.3 | 357 | 54.6 | 2.3 | 27 | 5.5 | 12.8 | 102 |
| One-half hour prior to death. | 18.3 | 20.0 | 500 | 108.0 | 2.0 | 71 | 5.3 | 12.4 | 70 |
| HORSE C. | | | | | | | | | |
| Before infection | 71.8 | 8.5 | 212 | 33.3 | 1.6 | ------- | ------- | ------- | 0 |
| Four days after infection. | 74.5 | 9.5 | 237 | 27.8 | 1.5 | 88 | 6.9 | 6.4 | 0 |
| Twenty-eight days after infection. | 57.9 | 10.5 | 262 | 25.0 | 1.6 | 105 | 2.7 | 5.9 | 18 |
| Forty-eight hours prior to death. | 52.3 | 12.2 | 305 | 29.0 | 2.0 | 95 | 3.0 | 8.6 | —1 |
| At death | 12.1 | 14.3 | 357 | 109.0 | 3.3 | 74 | ------- | ------- | 100+ |

Terminal determinations were made on unclotted blood collected from the ventricles of the heart in the case of horse C at death and one-half hour prior to death in the case of horse B. The increase in both red and white cell counts in the terminal stages of trypanosomiasis is assumed to be due to dehydration of the animals. The $CO_2$ combining capacity of the blood plasma being 18.3 and 12.1 for horses B and C, respectively, showed that the animals had marked terminal acidosis. The nonprotein nitrogen and creatinin determinations indicated that nephrosis was advanced. In horse C the blood sugar was at no time markedly decreased, but horse B had a blood sugar

of only 27 twenty-four hours previous to death, which had increased to 71 as shown by the specimen obtained only one-half hour before death, while the animal was in a moribund condition. In both cases the urine collected at autopsy was strongly positive for albumin.

Specimens of tissue were obtained for pathological examination, a report on which is not as yet available.

## DISCUSSION

The foregoing investigations have not established without doubt the mechanism of death in horses infected with *Trypanosoma evansi.* The results obtained support the theory that death is due to an asphyxia, although the factors leading to this condition are not clearly demonstrable.

It should be noted that in these horses, hypoglycæmia at time of death was not marked. The maintenance of an approximate normal blood sugar level may be explained by the lecithin content of the blood during the infection. It is known that fat circulates in the blood as a lecithinlike compound, and the production of sugar from fat, and of dextrose from glycerol, in the animal body, appears to be possible (Linton, 1930). At time of death, in the cases reported, body fat was almost absent other than a fair portion in the liver. In these horses the appetite, with certain exceptions for short periods, remained normal throughout the course of the disease.

The animals were continuously in a state of acidosis that varied at times according to the number of trypanosomes present in the blood stream. In the determinations made after a crisis, there was a marked scarcity of trypanosomes, the $CO_2$ capacity of the blood plasma and the blood sugar increased, and the latter at times was above normal. It appears that pathogenic trypanosomes use glucose to an extent that causes withdrawal of the body fat to the blood stream as lecithin, which is in turn converted into glucose. The abnormal blood sugar at times after a crisis indicates that conversion goes on at a rate that takes some time to stabilize and by this conversion the body is able to maintain an approximately normal sugar level until death approaches. The end products of glucose consumption cause an uncompensated acidosis and exhaustion of the alkali reserve, which is further adversely affected by the destruction of the red cells causing an anoxæmia that manifests itself by an ac-

celerated and labored respiration in the infected animal. As the animals reached the terminal stage of infection it was noted that there was an increase in both red and white cell counts, which may be assumed to be due to a terminal dehydration of the animal.

There is evidence that trypanosomes utilize carbohydrates in their metabolism and some workers believe that a hypoglycæmia may cause the death of trypanosomes in vivo. Whether or not this is a factor in the production of crises in an infected animal or that trypanocidal antibodies are the sole or major factor in the destruction of trypanosomes is not conclusively established. If there is any in vivo destruction of trypanosomes by a hypoglycæmia of the host, it has not been indicated by the findings in the infections with *Trypanosoma evansi* in equines herein reported.

## CONCLUSION

It is believed that *Trypanosoma evansi* causes death in equines not by the production of a toxic substance liberated by the disintegration of the organisms, nor by the exhaustion of the blood sugar and glycogen reserve, but by an asphyxia from an uncompensated acidosis, the mechanism of which is still undetermined.

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## A MOSQUITO NET FOR USE IN THE PHILIPPINE ISLANDS

### EXPERIMENTAL STUDIES AND CANVASS OF MATERIALS [1]

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TEN PLATES AND ONE TEXT FIGURE

### INTRODUCTION

Mosquito nets, sometimes called mosquito bars, bed nets, tents, or *mosquiteros,* have been used since very early times to protect

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man from the bites of mosquitoes. Von Kühlewein(1) and Hehir,(2) for instance, stated that Herodotus noted that several hundred years before Christ Egyptians had nets which were used in the daytime for fishing and in the nighttime as a protection against mosquitoes.

Schroeder(3) stated that Marco Polo in the thirteenth century in a description of a temple on the Coromandel Coast of India mentioned beds with curtains which could be closed by a purse string to keep out biting flies and other vermin.

Ross(4) stated that *conopeum,* or mosquito netting, sheltered wealthy Roman babies as they slept, and that such bed nets were alluded to by Herodotus, Varro, Horace, Propertius, Juvenal, and Paulus Silentiarius.

In the Philippines it would appear that *"mosquiteros"* were used by the Spaniards soon after they came to the Islands.

Blair and Robertson,(5) presenting a translation of Aduarte's Historia of 1640, include the following statement about the martyrdom of Father Fray Guillermo Cortet:

> The Province directed him to teach theology in the college of Sancto Thomas at Manila, which he did obediently, putting aside his desire to go to Japon. That he might have more time and ease in the holy exercise of prayer, he never undressed at night during the last twenty years of his life, but slept seated in a chair. This country is infested with multitudes of annoying mosquitoes; but he did not take advantage of the common means of preventing them, which is a tent, something permitted to all the religious. He would not accept one, but offered to the Lord the stings of the gnats, which is no small mortification and penance.

We have not been able to find any definite references to the use of such nets prior to the Spanish occupation. But Dr. H. O. Beyer,(6) and also Minier(7) and Miller,(8) stated that sinamay netting was woven in the Philippines before the Spaniards came. There are very early references by Chinese authors to this transparent cloth. Doctor Beyer(6) also noted that a net is used at one stage in typical Moro weddings. It therefore seems not unlikely that nets to ward off insects were used locally in very early times.

As to the usefulness of mosquito nets in the Philippines there is little doubt. In common with all tropical countries, these Islands have an abundant mosquito fauna. There are some twenty-seven species of *Anopheles,* several species of *Aëdes,* and some hundreds of species of *Culex.* Naturally, mosquito-borne diseases also abound. Malaria is known to be carried by *Anopheles minimus* var. *flavirostris,* and perhaps also by *A. filipinæ, A.*

*maculatus*, and *A. mangyanus*. Dengue is known to be carried by *Aëdes ægypti* and *Aëdes albopictus*. Filariasis is found to a limited extent and is probably carried by *Culex* species. Yellow fever has never occurred in the Philippines. *Culicoides* species are found in the Philippines, and sometimes bite annoyingly, but they are so small that no ordinary netting will keep them out. We do not recommend that nets be fine enough to exclude *Culicoides*, except under very special conditions. The standard net presented in this paper will not keep out these minute flies.

It is in prophylaxis against malaria that mosquito nets have the greatest potential value in the Philippines. Malarial fevers are found throughout the length and breadth of the Archipelago wherever there are fresh running streams. Practically all foothill areas are malarious. Exactly what the incidence of this disease is cannot be determined, because a very high percentage of illness in the provinces does not receive medical attention. It is the rule rather than the exception that cause of death, outside the populous centers, is diagnosed by laymen for the official reports, because physicians are not available. However, one of us(9) has recently ventured the opinion, based on all available evidence, that there are probably some 2,000,000 cases of malaria with more than 10,000 deaths yearly in the Philippines.

It seems likely that in this country the most important weapon against malaria is the mosquito net. There is practically nothing which the average citizen can do to combat this disease except to use a protecting net at night. Larva control is important but cannot be carried out by individual householders. It must be accomplished by community effort supervised by the Bureau of Health. Antimalaria drugs are essential but are so expensive that few can afford to take them in curative amounts.

To one unacquainted with this country the question might occur as to why it would not be better to advise the screening of houses or bedrooms rather than the use of bed nets. The answer becomes obvious when it is realized that, in common with many tropical countries of the Far East, most rural houses are made of woven materials loosely put together, with open eaves and with bamboo floors having wide cracks between the strips. In the Philippines a majority of rural habitations are made with woven strips of nipa palm leaf for walls, with floors of split bamboo laid in strips, 1 or 2 centimeters apart. Roofs are made of nipa palm, anajao palm, or cogon grass, occasionally of galvanized iron. The rooms have no ceilings and it is usual to see wide spaces between the top of the walls and the over-

hanging roof and around the windows and doors. These houses are usually on posts, 2 or 3 meters above the ground. They are light, dry, and airy, and are therefore not attractive to mosquitoes in the daytime.

It is not feasible to screen rural houses so constructed. In each town there are houses built of strong materials* in such a way as to make screening not only practical but preferable to bed nets. But by far the greater number of rural houses could not be mosquito-proofed at any reasonable cost. Moreover, even if screening were feasible it would not be tolerated during the daytime when it lessens comfort and has little anti-mosquito value.

There is no reason, theoretically, why every person living in a malarious region should not use a mosquito net. It is true that nets decrease slightly the circulation of air, but on the other hand they afford excellent assistance in malaria prophylaxis and offer welcome protection from myriads of insects. They can be made for a price within the means of the people.

Actually there are several practical reasons why nets are not widely used in malarious places. Suitable nets are usually not easily available. There is also an inertia of the masses to new devices not having immediate, obvious, and overwhelming advantages. This inertia is resistant beyond belief. Every artifice at the command of health officers must be used to overcome it.

In the case of mosquito nets it is essential that standard, cheap, effective nets be made available locally so that the householder, in supplying himself with a net, will be put to only the very minimum of effort. It will require active, incessant, house-to-house propaganda by health inspectors and, more especially, by health nurses.

The first reference to the use of mosquito nets in malaria prophylaxis in the Philippines is a circular by Lippincott reported by Love(26) as having been included in the Surgeon General's report from 1898. Lippincott advised the Army as follows: "Mosquitoes have been accused of causing malaria, and whether it is true or not, it is wise to protect ourselves from them. Mosquito netting is desirable." The United States Army reports thereafter repeatedly emphasize the importance of mosquito nets. In 1907, Vedder(10) devised a new net suitable for field use by the soldiers. Although the Army nets at first were not satisfactory, one of us(9) has expressed the opinion that, subsequent to 1906, nets appear to have reduced the incidence of

malaria in the Army by about 75 per cent. The use of these nets was strictly enforced. Page,(11) for example, noted that at the Lucena barracks men were even court-martialed for not using their mosquito nets properly.

Chamberlain, Vedder, and Barber(12) tested bronze mosquito netting against the passage of mosquitoes, experimenting with 8-, 12-, 14-, and 16-mesh, trying both vertical and horizontal partitions. Practical field tests were also carried out. It was found that 16-mesh bronze gauze was impervious to "*Myzomyia rossii,*" "*Myzorhynchus barbirostris,*" and "*Culex fatigans,*" but "*Stegomyia calopus*" passed through the 16-mesh wire gauze.

Manalang(13) reported that according to his observations "*A. minimus*" seemed to feed on humans chiefly between 10 p. m. and 2 a. m. He also noted that the wheal caused by its bite disappeared in one or two hours. These reports explain why infections may occur in the Philippines when the victims stoutly maintain that there were no mosquitoes biting them. The *minimus* adult is unobtrusive and spreads her sporozoites apparently late at night without attracting the attention of the householder. In this paper Manalang(13) also expressed the opinion that local mosquito nets require not less than sixteen meshes per linear inch.

In 1923 Tiedeman(14) reported that a survey of 1,600 persons revealed only 12.4 per cent using mosquito bars of any kind. He wrote, "the survey revealed that practically no efforts are being made by the people to protect themselves from the bites of mosquitoes. Mosquito bars are not in general use."

Recent mosquito-net surveys would seem to indicate that the use of such protection is becoming more general. For example, the following reports from Aritao, Nueva Vizcaya, and Calauan, Laguna, seem to indicate this.

*Mosquito-net survey, Aritao, Nueva Vizcaya Province, Luzon, 1933.*

| | |
|---|---|
| Total houses | 143 |
| Said to use nets | 94 |
| No nets in house | 49 |
| Parasite index, 299 persons examined | 31.8 |
| Splenic index, 31 examinations | 33.3 |

*Mosquito-net survey, Calauan, Laguna Province, Luzon, 1933.*

| | |
|---|---|
| Total population canvassed (poblacion) | 1,110 |
| Number of mosquito nets [a] | 407 |
| Parasite index, 76 school children | 28.9 |
| Splenic index, 76 school children | 40.8 |

[a] Several persons may sleep under one net; 117 persons stated that they did not use nets.

It is probable that any increase in the use of nets is due in large measure to the Bureau of Education. The home-economics section of this bureau requires needlework of its fifth-, sixth-, and seventh-grade girls. Since 1920 mosquito nets have been an optional part of this needlework, and since 1929 the usefulness of nets has been stressed, so that many of the girls make a net for their home as a part of their school work. Patterns are supplied them.

In our opinion it is by no means a hopeless task to persuade large numbers of people to use mosquito nets although many years and active coöperation by the Bureaus of Education and Health may be required.

At present it is difficult for the average householder to secure a suitable net. Many that are sold are of poor quality and have too large or too fine a mesh. Obviously, it is very important that proper nets be made easily available in every malarious community.

It is the purpose of this paper to suggest a suitable net made of local materials which can be sold to the people at a low price, a net which might perhaps become the standard mosquito net for rural areas in the Philippine Islands.

## SINAMAY NETTING

There are many kinds of netting for sale in the Philippines, made locally, in the United States, in Europe, or in Japan. In connection with this paper we accumulated eighty-four samples by local shopping and through the courtesy of the American Trade Commissioner, the governors of several provinces, and the Bureau of Plant Industry. Many types, sizes, colors, and qualities were represented in our collection. After considerable study and having compared prices and durability, we came to the conclusion that for widespread use in the provinces there is no netting superior to sinamay netting. This material, although somewhat lacking in uniformity, has the advantages of durability, inexpensiveness, and availability. It does not soil easily and dust can be readily shaken off. It is a product of Philippines manufacture and could therefore be used widely by the Bureaus of Health and Education for standard mosquito nets without conflicting in any way with "flag" laws requiring the use of local or American products. Some of the samples from the United States were of suitable mesh and were superior to sinamay in uniformity and appearance, but were more expensive.

According to Muller(15) the word "sinamay" means a gauzy fabric and may refer to cloth made from the fibers of pineapple, banana, maguey, or abacá. Usually, however, the term "sinamay cloth" refers to that made from abacá. In our report we mean the abacá textile whenever we use the word "sinamay." Occasionally sinamay cloth contains fibers of mercerized cotton or raw silk, interwoven with those of abacá. Sinamay is sometimes woven in stripes and plaids and in some cases it is colored or has simple designs, introduced by a crude and laborious method.

The abacá of the Philippines is not hemp, although "Manila hemp" is abacá fiber. According to Miller(8) abacá is *Musa textilis,* whereas true hemp is *Cannabis sativa.* The abacá is a species of banana indigenous to the Philippines. The abacá plant resembles the banana very closely, but may be distinguished by its narrower leaves and the fact that these tend to stand more erect, instead of flopping over lazily like the banana leaf (Plate 1, fig. 1).

Abacá plants grow to a height of from 9 to 20 feet. The trunk is composed chiefly of overlapping leaf sheaths. When the flower bud appears, the entire plant is cut off close to the ground. The leaf sheaths, 5 to 12 feet long, are stripped off and separated into layers 0.25 inch or less thick, which are split into strips 1 to 2 inches wide. While still fresh and green these strips are drawn under a bolo or knife which scrapes away the pulp and leaves the fibers clean and white (Plate 2, fig. 1). As they leave the hands of the stripper the fibers are usually 9 to 12 feet long. The fiber for weaving is sold in *manojos,* or "fist bundles," usually classified into five or six grades according to diameter. Frequently, the fiber is classified and knotted at the same time by specially trained workers. The portion of the fiber from the tip of the abacá stalk is much finer than the portion from the base. The two portions are usually cut apart and similar grades tied together.

From the outside sheath to the inner ones the fiber decreases in size and strength but increases in softness. This is also true of older and younger stalks. Abacá fibers are used in rope making because of their high tensile strength, resistance to water, their length, durability, and pliability. Much of the fiber is beaten by a wooden pestle in a wooden mortar. Sometimes a grooved block is used and the fiber, placed in the grooves, is

pounded by an iron bar. The pounding tends to soften the fiber and make it more brilliant.

Looms are usually made of bamboo and may be square or cylindrical, mostly of very simple construction. The types of looms vary in different provinces. The weaving of sinamay is essentially a home industry (Plate 1, fig. 2, and Plate 2, fig. 2).

The woven cloth is usually folded and soaked in lime water for two nights. (The lime is made by burning seashells.) Then the cloth is washed in sea or other salt water and dried in the shade. Bleaching is accomplished in various ways. Fermented coconut water, a pepperlike fruit called *batuan,* and a species of citrus somewhat like an orange, are the chief bleaching agents. Cloth may be stiffened with rice starch. The final drying is done on a frame, and the cloth is then pressed under a smooth polished log.

Both Miller(8) and Minier(7) state that the weaving of abacá cloth was already a widespread industry in the Philippines when Magellan arrived in Cebu in 1521.

Our references to abacá have been the following: Muller,(15) Miller,(8) Minier,(7) Storms,(16) Buck,(17) and Mathews.(18) We have followed Miller and Minier closely in the above account.

Sinamay cloth is woven in many provinces, especially Batangas, Albay, and Sorsogon. In Alitagtag, near Taal, Batangas, for example, the residents make about 30,000 meters of all kinds of netting, chiefly abacá sinamay, per month, with about 150 individuals weaving. This amount could be doubled if the demand were present.

Sinamay is usually woven in pieces 50 cm wide. The length varies according to the demand, but is usually about 40 meters. The wholesale prices vary from 5 to 8 centavos per meter of length, occasionally as high as 11 centavos. As a rule the threads are single, but sometimes they are doubled (Plate 3 and Plate 6, fig. 1).

Sinamay cloth must be washed carefully, patted rather than rubbed. Rice starch is usually patted into the cloth after washing. In drying it must be hung carefully to put even tension on the fibers. The proper technic for washing and drying piña and sinamay is widely known in the rural Philippines.

## MEASUREMENT OF MESH

There are many different kinds of mosquito netting, and a good deal of confusion has existed on the subject of measuring

this netting. MacArthur (19) was one of the first to call attention to this confusion but the situation is even worse than he reported. In that report he noted that "screencloth," or mosquito wire gauze, is measured by the number of holes per linear inch. Due regard must also be paid to the diameter of the wire. He also stated that cotton mosquito netting is not to be measured in the same way. The threads of the warp, and those of the bobbin or woof, are interwoven so that the mesh consists of two sets of parallel lines of holes intersecting one another at an angle of about 60°. These openings may be hexagonal or round. Such mesh is not measured by holes per linear inch.

In trying to determine mesh size of such cotton netting one first decides which is warp and which is woof, or bobbin. This is best done with a lens and it becomes easier with practice. Then 1 square inch of netting is marked off, and the holes along the line of the warp are counted and this count is added to the number of holes along the woof. An easy method is to cut out a hole 1 square inch in size in a piece of thin cardboard. This is then laid upon the netting so that the bottom edge is along a line of warp holes and the left hand corner at the intersection of the horizontal warp and a diagonal woof line. The mesh is the sum of the number of holes along the bottom edge of the square and the number of holes of the diagonal. The hole at the intersection is counted twice (Plate 6, fig. 2).

It is also clear that size of hole depends on size of thread. Two nets of different thread size may have the same mesh count, yet the hole of one may be small. In general, it is true that cotton netting having twenty-five to twenty-six holes, as counted above, made either of what in the trade is called "30/s" thread or of "40/60" thread, will exclude mosquitoes. But if one will consult Plates 3 to 5, inclusive, it will be seen that the matter is still more complicated. The samples of netting A to L, shown in the figures, are all made of cotton or abacá fibers and not of wire. Samples E, F, and G (Plate 4) would be counted according to the method just outlined. But how should the other samples of cloth netting be counted?

Samples A, B, and C (Plate 3) are locally made sinamay netting. In sample A the holes are rectangular with the fibers of the warp at right angles to those of the woof. The mesh of such netting would probably best be counted per linear inch along the warp and also along the woof and expressed as, for example, a mesh of 17 by 21. The same method might be ap-

plied to samples B and C, although the holes are more nearly square. Sample D is locally made cotton netting not suitable for mosquito nets. The counting of sample G and sample H, which are of Japanese weave, offer difficulties. In samples I to L, inclusive, the holes are square and the mesh of these cloth nettings should probably be counted in holes per linear inch as in wire gauze. Samples K and L are specially waxed so that they are very stiff and resemble wire netting.

It therefore appears that there are at least three ways of counting the mesh of mosquito netting, the proper method for each sample depending on the weave as follows:

1. *Holes per linear inch.*—Used for most wire netting and for cloth netting which is so woven that the threads of the warp are at right angles to those of the woof, and that the holes are square.

2. *Holes per linear inch of the warp times holes per linear inch of the woof.*—A new method suitable for Philippine sinamay netting in which the holes are rectangular, the threads of warp and woof being at right angles to each other.

3. *One line of holes along the warp added to one line of holes along the woof, within a square inch of cloth.*—Suitable for bobbinet and other cloth nettings having the threads of the woof running at an angle of about 60° to those of the warp and having roundish or hexagonal holes (Plate 6, fig. 2).

In all measurements the diameter of the fibers is important, as it obviously influences the size of the hole. It would simplify the whole matter if mosquito netting were bought and sold and experimented with on the basis of maximum and minimum diameters of the holes.

In our experiments we have followed the three methods of measuring mesh given above, but have also measured the diameters of the fibers and of the apertures.

## MOSQUITO PASSAGE EXPERIMENTS

It is now a platitude in malariology that the biology of anophelines varies from country to country and even in different regions of the same country. Therefore, it is a wise procedure to make specific laboratory and field tests in dealing with malaria problems. In the present instance, for example, it seemed wise to test various nettings against the passage of local mosquitoes, although it is fairly well established in the literature that certain meshes are most suitable, on the average, to keep out mosquitoes.

Covell,[20] for instance, gives a good résumé of the references. He notes that the cloth mosquito-netting supplied to the British Army in India is 25/26 mesh made of 30/s cotton. He cites MacArthur[19] as recommending wire screening of 14 mesh, with strands of 0.0124 inch diameter, and apertures of 0.0590 inch to exclude *Aëdes*. Le Prince and Orenstein[21] found that apertures in wire screening of 0.0485 inch would permit the passage of *Aëdes* under stress of special circumstances but apertures of 0.046 inch would exclude them altogether. Earle,[22] in Puerto Rico, found that a mesh of 16, with wire diameters of 0.009 or 0.010 inch and apertures of 0.0525 to 0.0530 inch, would keep out most mosquitoes. He reported that a 14-mesh, with wire diameters of 0.015 and apertures of 0.056 inch, was sufficient for many localities.

In another communication Earle[23] reported that the least obstruction to the movement of air from a fan was caused by a 12-mesh wire screen with 0.01 inch wire. He found that in Puerto Rico a 12-mesh screen with 0.015-inch wire will keep out most insects. It is also unusually durable.

The wire screen used by the British troops in India is 14-mesh, with strand diameters of 0.014 inch, and apertures of 0.055 to 0.057 inch.

## TECHNIC OF TESTS

It is true, as MacArthur[19] stated, that "we are not concerned with what mesh a frenzied mosquito imprisoned in a test tube may struggle through in order to escape from captivity, but with the mesh that a free mosquito will pass under natural conditions to obtain food." However, it is equally true that if a female mosquito of a malaria-carrying species can by its own efforts pass through a net, the mesh of that net must be considered as of doubtful safety, no matter what urge incited the insect to pull itself through the aperture. No net of any sort can be a part of "natural conditions," in the laboratory or out of it. The bed net and screened window are "unnatural" barriers between the insect and its food. It is well known that a mosquito will make persistent efforts to pass through a screen, with no greater stimulus apparently than hunger in the evening or a "homing instinct" in the early morning.

Therefore, we make no apologies for the technic of our tests, which included screened cylinders, lantern chimneys and cages, and one test of a full-size net in the field.

TABLE 1.—*Sinamay netting*[a] *(mesh 14.4 × 20.3) tested against the passage of Anopheles. Food and water attraction. Observations continued until all mosquitoes were dead.*

| Experiment No. | Mosquitoes. | | | |
|---|---|---|---|---|
| | Horizontal migration. | | Vertical migration. | |
| | Placed in chamber. | Passing the screen. | Placed in chamber. | Passing the screen. |
| 1 | 45 | 0 | 53 | 0 |
| 2 | 34 | 0 | 14 | 0 |
| 3 | 23 | 0 | 35 | 0 |
| 4 | 10 | 0 | | |
| Total | 112 | 0 | 102 | 0 |

[a] Measurements of sinamay of Tables 1 to 6 were as follows: Average size of apertures, 0.980 by 1.280 mm; maximum size of apertures, 1.350 by 2.400; minimum size of apertures, 0.750 by 1.050; maximum diagonal, 2.8; average diagonal, 1.620.

TABLE 2.—*Species of Anopheles used in tests 1 to 4 shown in Table 1.*

| Species. | Horizontal migration. | | Vertical migration. | | Total. |
|---|---|---|---|---|---|
| | Male. | Female. | Male. | Female. | |
| *A. barbirostris* | | 1 | | | 1 |
| *A. filipinæ* | 6 | 6 | 3 | 5 | 20 |
| *A. ludlowi* | | 1 | | | 1 |
| *A. maculatus* | 2 | 8 | | 2 | 12 |
| *A. mangyanus* | 3 | 8 | 14 | 14 | 39 |
| *A. minimus* var. *flavirostris* | 33 | 26 | 25 | 35 | 119 |
| *A. subpictus* var. *indefinitus* | 5 | 6 | | | 11 |
| Total | 56 | 56 | 44 | 58 | 214 |

TABLE 3.—*Sinamay netting (mesh 14.4 by 20.3) tested against the passage of Culex quinquefasciatus. Food and water attraction. Observations continued until all mosquitoes were dead.*

| Experiment No. | Mosquitoes. | | | |
|---|---|---|---|---|
| | Horizontal migration. | | Vertical migration. | |
| | Placed in chamber. | Passing the screen. | Placed in chamber. | Passing the screen. |
| 1 | 50 | 0 | 50 | 0 |
| 2 | 50 | 0 | 50 | 0 |
| 3 | 50 | 0 | 50 | 0 |
| Total | 150 | 0 | 150 | 0 |

TABLE 4.—*Sinamay netting (mesh 14.4 by 20.3) tested against the passage of Culex quinquefasciatus. Sex attraction. Horizontal migration.*

| Experiment No. | Mosquitoes. | | | | | |
|---|---|---|---|---|---|---|
| | Placed in chambers. | | Recovered dead in chambers. | | | |
| | | | I. | | II. | |
| | I. Male. | II. Female. | Male. | Female. | Male. | Female. |
| 1 | 39 | 39 | 39 | 0 | 0 | 39 |
| 2 | 42 | 42 | 42 | 0 | 0 | 42 |
| 3 | 40 | 40 | 40 | 0 | 0 | 40 |
| Total | 121 | 121 | 121 | 0 | 0 | 121 |

TABLE 5.—*Sinamay netting (mesh 14.4 by 20.3) tested against the passage of Aëdes ægypti. Food and water attraction.*

| Experiment No. | Mosquitoes. | | | | | |
|---|---|---|---|---|---|---|
| | Horizontal migration. | | | Vertical migration. | | |
| | Placed in chamber. | Passing the screen. | | Placed in chamber. | Passing the screen. | |
| | | | *Per cent.* | | | *Per cent.* |
| 1 | 12 | 1 | | 12 | 1 | |
| 2 | 58 | 16 | | 54 | 11 | |
| 3 | 52 | 7 | | 32 | 3 | |
| Total | 122 | 24 | 19.7 | 98 | 15 | 15.3 |

TABLE 6.—*Sinamay netting (mesh 14.4 by 20.3) tested against passage of Aëdes ægypti. Sex attraction. Horizontal migration. Eight and six-tenths per cent of the males and 9.1 per cent of the females passed through the screen.*

| Experiment No. | Mosquitoes. | | | | | |
|---|---|---|---|---|---|---|
| | Placed in chambers. | | Recovered dead in chambers. | | | |
| | | | I. | | II. | |
| | I. Male. | II. Female. | Male. | Female. | Male. | Female. |
| 1 | 15 | 21 | 13 | 4 | 2 | 17 |
| 2 | 20 | 23 | 19 | 0 | 1 | 23 |
| Total | 35 | 44 | 32 | 4 | 3 | 40 |

We used two cages in our first experiments. These cages measured 18 by 18 by 36 inches. Each was divided into two equal

TABLE 7.—*Sinamay netting of various mesh sizes tested against the passage of Anopheles mosquitoes. Vertical and horizontal migration with food and water attraction.*

| Test Nos. | Mesh size of netting.[a] Average. | Mesh size of netting.[a] Maximum. | Mesh size of netting.[a] Minimum. | Numbers of mosquitoes. | *A. barbirostris.* | *A. filipinæ.* | *A. ludlowi.* | *A. maculatus.* | *A. mangyanus.* | *A. minimus* var. *flavirostris.* | *A. subpictus* var. *indefinitus.* | *A. vagus* var. *limosus.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *mm.* | *mm.* | *mm.* | | | | | | | | | |
| 1 to 5 | 12.7 by 14.6 | 13 by 15 | 12 by 14 | Total used | 16 | 6 | ------ | 14 | 16 | 37 | ------ | |
| | | | | Passing screen | 0 | 1 | ------ | 0 | 3 | 11 | ------ | 0 |
| | | | | Passing screen, per cent | 0 | 16.7 | ------ | 0 | 18.8 | 29.7 | ------ | 0 |
| 6 to 9 | 13.4 by 15.6 | 14 by 16 | 12 by 15 | Total used | 7 | 1 | ------ | 9 | 21 | 15 | 1 | 1 |
| | | | | Passing screen | 0 | 0 | ------ | 0 | 1 | 2 | 0 | 0 |
| | | | | Passing screen, per cent | 0 | 0 | ------ | 0 | 4.8 | 13.3 | 0 | 0 |
| 10 to 12 | 11.3 by 16.6 | 12 by 17 | 11 by 15 | Total used | ------ | 5 | ------ | 13 | 10 | 10 | ------ | ------ |
| | | | | Passing screen | ------ | 0 | ------ | 0 | 0 | 3 | ------ | ------ |
| | | | | Passing screen, per cent | ------ | 0 | ------ | 0 | 0 | 30 | ------ | ------ |
| 13 and 14 | 11.7 by 20.9 | 12 by 21 | 11 by 20 | Total used | 6 | 1 | ------ | 4 | 8 | 8 | ------ | 1 |
| | | | | Passing screen | 0 | 0 | ------ | 0 | 0 | 0 | ------ | 0 |
| | | | | Passing screen, per cent | 0 | 0 | ------ | 0 | 0 | 0 | ------ | 0 |
| 15 to 17 | 17.1 by 17.2 | 18 by 18 | 17 by 17 | Total used | 18 | ------ | 1 | 4 | 12 | 15 | 1 | 1 |
| | | | | Passing screen | 0 | ------ | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | Passing screen, per cent | 0 | ------ | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 to 21 | 15.9 by 19.2 | 16 by 22 | 15 by 18 | Total used | 15 | 3 | ------ | 20 | 14 | 31 | 1 | 1 |
| | | | | Passing screen | 0 | 0 | ------ | 0 | 0 | 0 | 0 | 0 |
| | | | | Passing screen, per cent | 0 | 0 | ------ | 0 | 0 | 0 | 0 | 0 |

[a] Average of ten measurements at random.

compartments, one by a vertical and the other by a horizontal screen. These screens were composed of the netting to be tested. In other tests we used lantern chimneys separated by the screen to be tested. Finally we used glass cylinders, 2.75 by 3 inches, also separated by the screen to be tested. These various testing devices are shown on Plates 7 and 8.

TABLE 8.—*Sinamay netting of various mesh sizes tested against the passage of Culex mosquitoes. Vertical migration with food and water attraction. Culex quinquefasciatus.*

| Test Nos. | Mesh size.[a] | | | Mosquitoes. | | |
|---|---|---|---|---|---|---|
| | Average. | Maximum. | Minimum. | Used. | Passing net. | |
| | *mm.* | *mm.* | *mm.* | | | *Per cent.* |
| 1 to 4 | 12.7 by 14.6 | 13 by 15 | 12 by 14 | 87 | 28 | 32.2 |
| 5 to 8 | 13.4 by 15.6 | 14 by 16 | 12 by 15 | 94 | 6 | 6.4 |
| 9 to 12 | 11.3 by 16.6 | 12 by 17 | 11 by 15 | 107 | 29 | 27.1 |
| 13 to 16 | 15.9 by 19.2 | 16 by 22 | 15 by 18 | 90 | 1 | 1.1 |
| 17 to 20 | 17.1 by 17.2 | 18 by 18 | 17 by 17 | 98 | 0 | 0.0 |
| 21 to 24 | 11.7 by 20.9 | 12 by 21 | 11 by 20 | 101 | 0 | 0.0 |

[a] Average of ten measurements at random.

TABLE 9.—*Sinamay netting of various mesh sizes tested against the passage of Aëdes mosquitoes. Vertical migration with food and water attraction.*

| Meshes per linear inch. | Test Nos. | Mosquitoes. | | | |
|---|---|---|---|---|---|
| | | Species. | Total. | Passing through holes of net. | |
| | | | | | *Per cent.* |
| Average 12.7 by 14.6<br>Minimum 12 by 14<br>Maximum 13 by 15 | 1– 4 | *Aëdes albopictus*<br>*Aëdes ægypti* | 4<br>31 | 4<br>28 | 100.0<br>90.3 |
| Average 11.3 by 16.6<br>Minimum 11 by 15<br>Maximum 12 by 17; 11 by 18 | 5– 9 | *Aëdes albopictus*<br>*Aëdes ægypti* | 12<br>32 | 5<br>15 | 41.7<br>46.9 |
| Average 13.4 by 15.6<br>Minimum 12 by 15<br>Maximum 14 by 16 | 10–14 | *Aëdes albopictus*<br>*Aëdes ægypti* | 8<br>28 | 3<br>16 | 37.5<br>57.1 |
| Average 15.9 by 19.2<br>Minimum 15 by 18<br>Maximum 16 by 22 | 15–19 | *Aëdes albopictus*<br>*Aëdes ægypti* | 21<br>42 | 7<br>9 | 33.3<br>21.4 |
| Average 11.7 by 20.9<br>Minimum 11 by 21; 12 by 20<br>Maximum 12 by 21 | 20–24 | *Aëdes albopictus*<br>*Aëdes ægypti* | 7<br>52 | 0<br>9 | 00.0<br>17.3 |
| Average 17.1 by 17.2<br>Minimum 17 by 17<br>Maximum 18 by 18 | 25–29 | *Aëdes albopictus*<br>*Aëdes ægypti* | 5<br>35 | 0<br>3 | 00.0<br>8.6 |

In our first test we used a local sinamay cloth having an average mesh of 14.4 by 20.3. This netting is being used for mosquito nets in some localities. The results of tests with *Anopheles* mosquitoes are shown in Tables 1 and 2; with *Culex* mosquitoes in Tables 3 and 4; and with *Aëdes* mosquitoes in Tables 5 and 6. In the case of *Anopheles* the tests were on the basis only of food and water attraction, the mosquitoes being placed in one compartment and a cut mango and water in the other compartment. In these tests no *Anopheles* made either vertical or horizontal passage through the netting.

*Culex* and *Aëdes* were tested in the same way for vertical and horizontal passage. They were also tested by sex attraction, males being placed in one chamber and females in the other. In no test did any *Culex quinquefasciatus* pass through the netting, but some *Aëdes ægypti* succeeded in passing this mesh in each test. All of the mosquitoes used in these tests were bred out in the laboratory.

Measurements of sinamay of Tables 7, 8, and 9 were as follows:

| Average mesh per linear inch. | Average size of apertures in millimeters. |
|---|---|
| 12.7 by 14.6 | 1.435 by 1.745 |
| 11.3 by 16.6 | 1.240 by 1.540 |
| 13.4 by 15.6 | 1.340 by 1.615 |
| 15.9 by 19.2 | 1.180 by 1.260 |
| 11.7 by 20.9 | 1.110 by 1.660 |
| 17.1 by 17.2 | 1.140 by 1.360 |

TABLE 10.—*Measurements of dead mosquitoes (greatest diameter in millimeters).*[a]

| Species. | Maximum. | Minimum. | Average. |
|---|---|---|---|
| *Lutzia fuscana* | 3.40 | 2.22 | 2.31 |
| *Culex quinquefasciatus* | 1.59 | 1.52 | 1.56 |
| *Anopheles barbirostris* | 1.46 | 1.17 | 1.33 |
| *Anopheles filipinæ* | 1.11 | 0.86 | 0.96 |
| *Anopheles maculatus* | 1.18 | 1.04 | 1.11 |
| *Anopheles mangyanus* | 1.20 | 0.94 | 1.09 |
| *Anopheles minimus* var. *flavirostris* | 1.10 | 0.85 | 0.99 |
| *Aëdes ægypti* | 1.37 | 1.01 | 1.14 |
| *Aëdes albopictus* | 1.50 | 1.11 | 1.29 |

[a] These measurements were made on dried specimens several days old. Ten female mosquitoes of each species were measured, several measurements of each specimen being taken. Bred out mosquitoes were used. In these specimens the greatest diameter was always through the thorax and included the coxa and a portion of the trochanter of the middle leg on the side measured. See diagram. (Courtesy of Mr. J. Espinosa, division of weights and standards, Bureau of Science.)

TABLE 11.—*Measurements of living female mosquitoes.*[a]

| Species. | Source. | Number. | Measurement of thorax. | | |
|---|---|---|---|---|---|
| | | | Maximum. | Minimum. | Average. |
| | | | *mm.* | *mm.* | *mm.* |
| *Anopheles filipinæ* | Caught wild | 10 | 1.20 | 1.10 | 1.14 |
| *Anopheles mangyanus* | do | 18 | 1.30 | 1.12 | 1.19 |
| *Anopheles minimus* var. *flavirostris* | do | 81 | 1.25 | 1.03 | 1.13 |
| Do | Bred out | 6 | 1.10 | 0.95 | 1.06 |
| *Culex quinquefasciatus* | do | 100 | 1.85 | 1.45 | 1.72 |
| *Aëdes ægypti* | do | 35 | 1.73 | 1.45 | 1.58 |

[a] The anophelines were from Laguna and Nueva Vizcaya Provinces. The culicines were from Pasay, Rizal, and the aëdines from Manila. The greatest diameter was taken. This was always through the thorax and included the coxa and a portion of the trochanter of the middle leg on the side measured. Living mosquitoes quieted by chloroform, were used. (Courtesy of Mr. F. E. Baisas, Malaria Investigations laboratory.)

Tables 7, 8, and 9 summarize the results of numerous tests with *Anopheles, Culex,* and *Aëdes,* respectively, against various sizes of sinamay netting. From Table 7 it will be seen that anophelines do not pass netting having a mesh of 11.7 by 20.9 or more. But malaria-carrying *A. minimus* var. *flavirostris* will pass a mesh of 11.3 by 16.6. Of the three mosquitoes of this species passing this netting, two were females and one was a male.

From Table 8 it will be seen that *Culex quinquefasciatus* did not succeed in passing the sinamay netting having an average of 17.1 by 17.2 or 11.7 by 20.9. One of 90 passed through a net of 15.9 by 19.2 average mesh.

From Table 9 it will be seen that aëdines were able to pass apertures which culicines and anophelines could not pass.

In Tables 10 and 11 are given the results of some measurements of living and dead female mosquitoes of several species (text fig. 1). It will be seen from these tables that, unfortunately, the malaria-carrying species of the Philippines are among the smallest mosquitoes. In Table 10, for example, dead females of *A. minimus* var. *flavirostris,* the chief carrier, had an average largest diameter of 0.99 mm. The living specimens of this species, as shown in Table 11, had an average diameter of 1.13, wild-caught, and 1.06, bred out. The apertures of our proposed standard net average 1.18 by 1.215 mm, so that, theoretically, *A. minimus* var. *flavirostris* could pass the apertures. Actually, in all of our laboratory tests and our field trials, no

passing occurred; but these measurements indicate that the mesh chosen is at about the theoretical limit desirable. Comfort requirements make advisable the largest safe mesh.

It is apparent that some species of mosquitoes are more agile than others in penetrating a net. Just as *Aëdes ægypti* has become more adapted to house conditions, is more clever about attacking from the rear, and is more elusive to hand-catching, so it is cleverer in getting through a net. With an average greatest diameter of 1.58 mm it will pass apertures averaging 1.18 by 1.215 mm. We have made special observations to see why this should be so, and we find that *Aëdes ægypti* utilizes the diagonal size of the aperture. A rectangular hole measuring 1.18 by 1.215 mm has a diagonal measurement of 1.694 mm, and this is sufficient for *Aëdes* averaging 1.58 mm. Several times we have observed *Aëdes* passing such a net. The insect at first apparently searches for the most suitable aperture. It then pushes one foreleg and its head through this hole. Then it hooks the tibia of its protruding foreleg over a thread, and pulls itself through, making full use of the diagonal. Rarely, both forelegs protrude with the head and are hooked over a thread. The mid and hind legs and the wings offer no difficulties folded back along the abdomen. The insect, however, is not infallible. Sometimes it inserts the forelegs in holes adjacent to the one it is trying to pass. This naturally complicates matters so that there is failure to pass.

In one case we measured an aëdine that we had seen pass a certain hole, which we also measured. The greatest diameter of the mosquito was 1.73 mm. The rectangular hole measured 1.70 by 1.65 mm with a diagonal of 2.36 mm. The mosquito came through without any difficulty, its sternum turned toward one corner and its dorsum toward the opposite corner.

## FIELD TEST

A net made of sinamay having a mesh of 15.9 by 19.2, threads averaging 0.328 mm, and apertures averaging 1.18 by 1.25 mm, was tested in Calauan, Laguna, where *Culex*, *Aëdes*, and the *funestus-minimus* subgroup of anophelines are abundant. It was used for ten nights with careful observations during each night and morning. No mosquitoes entered the net during this period to feed on the person sleeping within it. Daily collections of *funestus-minimus* adults were made in natural daytime shelters nearby during the period of observation.

TABLE 12.—*Passage of wind through netting using fan alone. No tunnels to straighten wind current.*

| Test No. | Conditions. | Anemometer readings. M/min.[a] | | | | | | Effect of screen. | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Average. | Difference. | Wind passing screen. |
| | | | | | | | | *M/min.* | *Per cent.* |
| 1 | No screen | 102 | 117 | 118 | 90 | 91 | 104 | | |
| | 18-mesh copper | 0 | 0 | 0 | 0 | 0 | 0 | 104 | 00.0 |
| 2 | No screen | 90 | 120 | 130 | 130 | 121 | 118 | | |
| | No. 2 sinamay | 0 | 0 | 0 | 0 | 0 | 0 | 118 | 00.0 |
| 3 | No screen | 102 | 118 | 120 | 117 | 95 | 110 | | |
| | No. 6 cotton | 0 | 0 | 0 | 0 | 0 | 0 | 110 | 00.0 |
| 4 | No screen | 220 | 218 | 216 | 220 | 218 | 218 | | |
| | 18-mesh copper | 75 | 74 | 75 | 78 | 80 | 76 | 142 | 34.9 |
| 5 | No screen | 210 | 212 | 220 | 208 | 212 | 212 | | |
| | No. 2 sinamay | 41 | 40 | 45 | 40 | 42 | 42 | 170 | 19.8 |
| 6 | No screen | 215 | 220 | 218 | 216 | 200 | 214 | | |
| | No. 6 cotton | 27 | 25 | 20 | 28 | 30 | 26 | 188 | 12.1 |

[a] Meters per minute.

TABLE 13.—*Passage of wind through netting. Wind from fan straightened by tunnels.*[a]

| Test No. | Conditions. | Anemometer readings. M/min. | | | | | | Effect of screen. | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | Average. | Difference. | Wind passing screen. |
| | | | | | | | | *M/min.* | *Per cent.* |
| 1 | No screen | 98 | 90 | 92 | 97 | 102 | 96 | | |
| | 18-mesh copper | 70 | 73 | 75 | 79 | 78 | 75 | 21 | 78.1 |
| 2 | No screen | 105 | 107 | 110 | 106 | 104 | 106 | | |
| | No. 2 sinamay | 78 | 79 | 79 | 83 | 77 | 79 | 27 | 74.5 |
| 3 | No screen | 109 | 112 | 113 | 115 | 114 | 113 | | |
| | No. 6 cotton | 70 | 74 | 72 | 73 | 73 | 72 | 41 | 63.7 |
| 4 | No screen | 177 | 175 | 178 | 182 | 180 | 178 | | |
| | 18-mesh copper | 124 | 130 | 131 | 128 | 128 | 128 | 60 | 71.9 |
| 5 | No screen | 177 | 188 | 186 | 185 | 197 | 187 | | |
| | No. 2 sinamay | 127 | 127 | 120 | 125 | 127 | 125 | 62 | 68.9 |
| 6 | No screen | 185 | 187 | 187 | 192 | 195 | 189 | | |
| | No. 6 cotton | 118 | 117 | 117 | 124 | 125 | 120 | 69 | 63.5 |

[a] The No. 2 sinamay mesh was on the average 15.9 by 19.2 with a minimum of 15 by 18 and a maximum of 16 by 22. The No. 6 cotton cloth had a mesh of 17 by 21 with rectangular holes. The strand sizes were: Copper wire, 0.298 mm; sinamay fibers, 0.328 mm; cotton fibers, 0.172 mm.

## WIND PASSAGE EXPERIMENTS

In Tables 12 and 13 are given the results of some tests of various kinds of netting as regards the amount of wind that they would allow to pass. An electric fan was used as the source of wind, and this appears to have been the usual proce-

dure in similar experiments reported elsewhere. Table 10 gives the results when the fan was used, blowing directly on the net at right angles to the blades of the fan. Tests were made with three materials as follows:

A. 18-mesh copper.
   Average diameter of wire, 0.298 mm (0.0117 inch).
   Average diameter of aperture, 1.068 by 1.100 mm (0.0421 by 0.0433 inch).

B. Sinamay netting No. 2. Mesh, 15.9 by 19.2.
   Average diameter of fibers, 0.328 mm (0.0129 inch).
   Average diameter of aperture, 1.180 by 1.215 mm (0.0465 by 0.0479 inch). (Rectangular.)

C. Cotton netting No. 6. Mesh, 17 by 21.
   Average diameter of fibers, 0.212 mm (0.0084 inch).
   Average diameter of aperture, 1.307 by 0.960 mm (0.0515 by 0.0388 inch). The mesh of this cotton netting was measured like that of sinamay because the warp and the woof were at right angles to each other and the holes rectangular.

In each case tests were made at two speeds of the fan. In each test the speed of the wind from the fan was first measured in meters per minute, five times without the screen and then immediately five times with the screen interposed between fan and anemometer, an average speed being determined in this way in each test.

It will be seen in Table 12 that when the wind velocity was 104, 118, and 110 meters per minute without the screen, it became zero with a screen, whether the screen was of copper, sinamay, or cotton. In other words 100 per cent of the wind was kept out by the screen. At velocities of 218, 212, and 214 meters per minute some of the wind passed the screen, as follows:

| Material. | Wind passing through. Per cent. |
|---|---|
| Wire screen | 34.9 |
| Sinamay netting | 19.8 |
| Cotton netting | 12.1 |

Wind as it leaves a fan must be swirling and is probably not traveling in a straight line, as does wind coming into a room where a bed net is in use. Therefore, a second series of tests were made with a number of paper tunnels placed between the fan and the screen. These tunnels were 11 inches long and in tests 1 to 3 had diameters averaging 0.8 inch. In tests 4 to 6 the tunnels were of the same length, but had diameters averag-

ing 1.28 inches. The purpose of these tunnels was to straighten out the wind currents so that they would strike the netting at right angles to the apertures, as would normally be the case with a net hanging in a room exposed to a natural wind. Table 13 gives the results of these tests, and it will be seen that there was a marked difference. In tests 1 to 3, Table 13, the average velocity of the wind without a screen was 96, 106, and 113 meters per minute. Although in the first series (Table 12), the screens allowed no wind to pass at approximately these velocities, we found that having straightened the currents with the tunnels, a considerable amount of wind passed through the screens, as follows:

| Material. | Wind passing through. Per cent. |
|---|---|
| Copper wire | 78.1 |
| Sinamay | 74.5 |
| Cotton | 63.7 |

With the larger tunnels (Table 11, Nos. 4–6) the velocities without the screen were 178, 187, and 189. About the same percentage of wind passed the screens, as follows:

| Material. | Wind passing through. Per cent. |
|---|---|
| Copper wire | 71.9 |
| Sinamay | 68.9 |
| Cotton | 63.5 |

Therefore, it would appear that, in testing netting for wind passage, if an electric fan is employed the wind currents must be straightened by some such device as we have used. Simple confirmation of the fact that much of the air directly from the fan is deflected when it strikes the net, may be had by placing the hand to one side of the screen being tested. Without the tunnels a strong current of deflected air is felt. With the tunnels the volume of deflected air is noticeably very much less. The swirling of the air currents from a fan may also be demonstrated by blowing smoke in front of the blades of the fan. We are indebted to Capt. Guy Hill, United States Army, for suggestions in regard to the use of tunnels in these tests.

These tests show that sinamay netting is better than cotton netting as regards the passage of wind. Wire netting is better than sinamay. Sinamay appears to keep out about 25 to 30 per cent of the wind that strikes the net squarely.

TABLE 14.—*Effect of screening on wet-bulb thermometer readings. Wind direct from fan. No tunnels.*

| Conditions. | Time required to lower wet bulb to minimum.[a] | |
|---|---|---|
| | First series. | Second series. |
| | *Seconds.* | *Seconds.* |
| No screen | 50 | 55 |
| Do. | 50 | 55 |
| 18-mesh copper | 95 | 100 |
| No. 2 sinamay | 106 | 105 |
| No. 6 cotton | 120 | 125 |

[a] During these tests the maximum dry-bulb reading was 83.8; minimum, 83. The maximum wet-bulb reading was 78.8; minimum, 77. The actual sizes of the screens used are given in Table 18.

TABLE 15.—*Effect of screening on wet-bulb thermometer readings. Wind from fan straigtened by tunnel.*

| Conditions. | Time required to lower wet bulb to minimum.[a] | |
|---|---|---|
| | First series. | Second series. |
| | *Seconds.* | *Seconds.* |
| No screen | 45 | 50 |
| 18-mesh copper | 55 | 50 |
| No. 2 sinamay | 60 | 55 |
| No. 6 cotton | 75 | 70 |

[a] During these tests the maximum dry-bulb reading was 84.2; minimum, 84. The maximum wet-bulb reading was 79, minimum, 77.9. The actual sizes of the screens used are given in Table 18.

## WET- AND DRY-BULB EXPERIMENTS

In Tables 14 and 15 are given the results of some tests with a wet-bulb thermometer, and in Tables 16 and 17 tests with the wet- and dry-bulb Kata-thermometer of Leonard Hill. These readings might be called comfort or evaporation tests. The tests were made with fans with and without the tunnels mentioned above. Here again it will be seen that the effect of the tunnels was marked, more wind passing through the various nets when the tunnels were used to straighten out the air currents. In all of the tests the degree of comfort indicated was greatest in the wire netting and least in the cotton netting. In Tables 14 and 15 are given the number of seconds required to lower the wet-bulb thermometer to its minimum reading. Using the

tunnels, it required between 45 and 50 seconds to lower the thermometer reading to its minimum without a screen, 50 to 55 seconds with a wire screen, 55 to 60 with sinamay, and 70 to 75 with cotton netting. This would seem to indicate that a sinamay netting might reduce the comfort of a sleeping person by about 14 per cent. Considering the fact that the average rural dweller in the Philippines in the past has as a rule closed all windows at night, it is not likely that this difference would be very noticeable. Certainly, freedom from the bites of mosquitoes and obviating the need for covering the face with a blanket, as has been a common habit, would more than compensate for this difference in comfort between no net and a sinamay net. Wire screening would no doubt be more comfortable than a sinamay bed net, but, as explained above, the average rural house in the Philippines could not be screened at a reasonable cost.

TABLE 16.—*Tests of netting with Kata-thermometer. Without tunnels.*

| Description.[a] | Without screen. | 18-mesh wire. | No. 2 sinamay. | No. 6 cotton. |
|---|---|---|---|---|
| Dry Kata-thermometer: | | | | |
| Time in seconds | 127.5 | 151.5 | 161.0 | 176.5 |
| Cooling power in millicalories | 3.7 | 3.1 | 2.9 | 2.6 |
| Wet Kata-thermometer: | | | | |
| Time in seconds | 27.0 | 30.0 | 32.0 | 38.5 |
| Cooling power in millicalories | 17.3 | 15.5 | 14.5 | 12.1 |

[a] The time in seconds is the time required to reduce the thermometer fluid from 100° to 95° C. The cooling power of the dry Kata is that by radiation and convection. The cooling power of the wet Kata is that by radiation, convection, and evaporation. The figures in millicalories are computed from the table supplied with the instrument in millicalories per square centimeter per second. The size of the mesh is given in Table 18. Room temperature, dry bulb, 29.5° C.; wet bulb, 26° C.

TABLE 17.—*Tests of netting with Kata-thermometer, using tunnels to straighten wind currents.*

| Description.[a] | Without screen. | 18-mesh wire. | No. 2 sinamay. | No. 6 cotton. |
|---|---|---|---|---|
| Dry Kata-thermometer: | | | | |
| Time in seconds | 86.5 | 106.0 | 126.5 | 131.5 |
| Cooling power in millicalories | 5.4 | 4.4 | 3.7 | 3.5 |
| Wet Kata-thermometer: | | | | |
| Time in seconds | 20.5 | 25.5 | 28.0 | 29.5 |
| Cooling power in millicalories | 22.7 | 18.3 | 17.0 | 16.0 |

[a] The note of Table 16 applies to this table also. We are indebted to Dr. S. Arima for his assistance in the tests summarized in Tables 16 and 17.

TABLE 18.—*Measurements of screening.*[a]

| No. | Copper, 18-mesh. | | | Sinamay, No. 2. | | | Cotton, No. 6. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Wire. | Aperture. | | Thread. | Aperture. | | Thread. | | Aperture. | |
| | | 1 | 2 | | 1 | 2 | 1 | 2 | 1 | 2 |
| 1 | 18 | 65 | 68 | 19 | 73 | 60 | 15 | 13 | 71 | 60 |
| 2 | 19 | 62 | 66 | 15 | 60 | 84 | 17 | 17 | 76 | 59 |
| 3 | 19 | 63 | 63 | 28 | 89 | 56 | 11 | 19 | 81 | 60 |
| 4 | 18 | 67 | 65 | 19 | 65 | 90 | 8 | 11 | 77 | 58 |
| 5 | 17 | 58 | 68 | 16 | 65 | 70 | 10 | 15 | 75 | 60 |
| 6 | 17 | 60 | 66 | 24 | 75 | 84 | 8 | 14 | 85 | 51 |
| 7 | 16 | 67 | 62 | 30 | 66 | 83 | 6 | 18 | 65 | 50 |
| 8 | 19 | 67 | 67 | 19 | 67 | 70 | 9 | 12 | 77 | 60 |
| 9 | 17 | 67 | 67 | 30 | 66 | 52 | 8 | 18 | 87 | 53 |
| 10 | 19 | 65 | 68 | 16 | 82 | 80 | 11 | 14 | 80 | 65 |
| 11 | ------ | ------ | ------ | 18 | ------ | ------ | ------ | ------ | ------ | ------ |
| 12 | ------ | ------ | ------ | 22 | ------ | ------ | ------ | ------ | ------ | ------ |
| 13 | ------ | ------ | ------ | 13 | ------ | ------ | ------ | ------ | ------ | ------ |
| 14 | ------ | ------ | ------ | 17 | ------ | ------ | ------ | ------ | ------ | ------ |
| 15 | ------ | ------ | ------ | 15 | ------ | ------ | ------ | ------ | ------ | ------ |
| 16 | ------ | ------ | ------ | 21 | ------ | ------ | ------ | ------ | ------ | ------ |
| 17 | ------ | ------ | ------ | 16 | ------ | ------ | ------ | ------ | ------ | ------ |
| 18 | ------ | ------ | ------ | 17 | ------ | ------ | ------ | ------ | ------ | ------ |
| 19 | ------ | ------ | ------ | 25 | ------ | ------ | ------ | ------ | ------ | ------ |
| 20 | ------ | ------ | ------ | 14 | ------ | ------ | ------ | ------ | ------ | ------ |
| Total | 179 | 641 | 660 | 394 | 708 | 729 | 103 | 151 | 784 | 576 |
| Average | 17.9 | 64.1 | 66.0 | 19.7 | 70.8 | 72.9 | 10.3 | 15.1 | 78.4 | 57.6 |
| Average mm | 0.298 | 1.068 | 1.100 | 0.328 | 1.180 | 1.215 | 0.172 | 0.252 | 1.307 | 0.960 |

[a] Except in the bottom row all figures are in micrometer spaces. One space equals 1/60 millimeter. The bottom row gives average figures in millimeters. The No. 1 columns refer to warp threads or to apertures along the line of the warp. The No. 2 columns refer to the woof. The mesh of sinamay sample No. 2 was 15.9 by 19.2 and that of cotton Number 6 was 17 by 21, the holes in each case being rectangular. (For conversion of millimeters to inches multiply by 0.0394.)

In Tables 16 and 17 are the results of the Kata wet-bulb and dry-bulb thermometer readings. The dry-bulb readings are a measure of heat loss by radiation and convection. The wet-bulb readings not only give a measure of loss by radiation and convection but also by evaporation. As in the other tests, it will be noted that the best netting, as regards comfort, is the wire screen. The sinamay is second, and the cotton netting third.

In these tables the heat loss in millicalories per square centimeter per second is estimated, using the factor 466 assigned to the particular Kata-thermometer we used. This factor divided by the cooling time in seconds gives the estimated heat loss. It will be seen that in these tests the screens slowed

down the heat loss, cotton netting by as much as 30 to 35 per cent and wire netting by as little as 10 to 20 per cent, approximately. The sinamay netting slowed the time by from 15 to 25 per cent, approximately.

Many more readings would have to be taken before the loss of comfort due to netting of a particular make could be stated definitely, but the tests reported are sufficient to indicate clearly the relative status of wire, sinamay, and cotton, and to demonstrate that the comfort loss although real is not great enough to be a serious drawback to the use of a sinamay net.

## A STANDARD MOSQUITO BED NET

There are certain points about a mosquito net for use with beds, as noted by various observers and summarized by one of us,(24) that require emphasis.

(*a*) The size of mesh is important. The optimum is the size that is just small enough to exclude mosquitoes. A smaller mesh tends to curtail the circulation of air unnecessarily and will not be used consistently by laymen.

In the Philippines we are interested principally in excluding anophelines of the *funestus-minimus* subgroup and *Anopheles maculatus*. From our experiments we believe that sinamay netting of about 16 by 20 average mesh, with fibers averaging 0.328 mm, and with average apertures of 1.180 by 1.215 mm, will exclude all anophelines, all culicines, and most aëdines. We believe such sinamay netting to be a satisfactory material for local mosquito nets.

(*b*) It is best to use white netting, as mosquitoes are more easily seen against such a background. Not only the sides but also the top of the mosquito bar should be of netting, for the sake of better circulation of air. When cotton is used the bottom should be of strong material, and the seams require reënforcement with tape. Sinamay nets do not require tape at the seams.

Sinamay netting is not white but a light cream color. It is occasionally dyed in various colors, but the undyed netting is best. While it might be somewhat better if the bottom of the net were made of some such material as calico, it is not necessary and it increases the cost of the net. The entire net may well be made of sinamay.

(*c*) The shape of the net requires attention. It should not be conical but rectangular. No openings should be provided for entrance or exit. To enter a net the user should lift the bottom

carefully and should slip inside quickly. Of course, no rent or wide separation of fibers should be tolerated, as mosquitoes will spend much time searching for such places.

(*d*) The hanging of the net is also important. Sometimes a wide four-poster bed can be used, the net being hung inside the posts and carefully tucked under the mattress all around. Nets should not sag or hang loosely. They should be put in place before dark and always searched for stray mosquitoes. The top should be about 4 feet above the bed, and there should be a foot of excess cloth at the bottom to be tucked under the mattress.

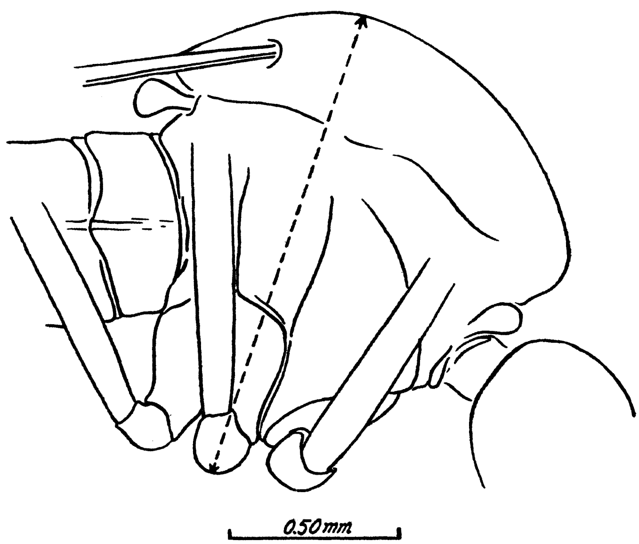


FIG. 1. Diagrammatic sketch showing line along which greatest diameter of mosquitoes was measured.

When the net is to be hung outside the bed posts it must be much longer, for at least a foot of excess must rest on the floor. In this case there is great danger of mosquitoes hiding under the bed and being inclosed with the sleeper in the net. Only very careful spraying and brushing will drive out these net mates, and it is for this reason that tuck-in nets are usually more effective. There is better circulation of air under the larger nets, however.

In the Tropics most persons, especially in the country, sleep without mattresses, so that there is nothing under which to tuck a mosquito net. Moreover, floors may be loosely made, so that a net hanging outside the bed to the floor is poor protection.

The beds also are often very loosely made. These conditions obtain in the rural Philippines. In such cases it is well to advise that a closely woven mat (*banig*) cover the surface of the bed or floor. Then a mosquito net may be used which has tunnels at the level of the bed parallel to the four lower edges of the net. Through these tunnels bamboo poles may be placed (Plates 9 and 10) or the tunnels may be weighted with stones. At least a foot of excess netting must be available below the tunnel to be tucked carefully under the bamboo poles or stones. A wide, long bed is advisable, so that elbows or knees or toes will not press against the net. Such a country net has been successfully used in the Dutch East Indies and would do very well in rural Philippines. They are especially suitable for those who sleep on the floor. We do not know to whom belongs the credit for this idea. In 1927, one of us (P. F. R.) saw such nets in use in Java.

It is a health officer's duty to make practical mosquito nets available to his people. Arrangements for the manufacture and the sale of nets can always be made without much difficulty and at reasonable cost. It seems to us that the first step in malaria prophylaxis to be undertaken by a health officer in the Philippines should be the making of necessary arrangements for the sale of suitable mosquito nets locally. Then this officer should actively and energetically attempt to persuade his constituents to buy and to use them.

## SIZE OF STANDARD NET

We propose for a standard net for the use of one person the following dimensions: Length, 188 cm; width, 100; height, 150; tunnel width, 12. This would require 23 meters of sinamay netting, 50 cm wide, as usual. Each side would consist of three strips of sinamay, each 50 cm wide, sewn together lengthwise to make the height of 150 cm, requiring 3 by 188, or 564 cm, for each side, a total of 1,128 cm for both sides. Each end would consist of three strips of sinamay (continuations of the side) each 50 cm wide; that is, 3 by 100 or 300 cm for each end, a total of 600 cm for the ends. The top would require two strips, each 188 cm long, a total of 376 cm. The tunnel would require one strip 50 cm wide and 188 cm long cut lengthwise into four pieces each 12 cm wide, two being 188 cm long and two being 100 cm long. This would leave a piece of netting 88 by 25 cm

for loops. To summarize, the amount of netting, 50 cm wide, needed would be for the sides, 1,128 cm; ends, 600; top, 376; tunnel, 188; total, 2,292 cm.

Therefore, 23 meters of sinamay netting would make a net suitable for one person sleeping on either a single or a double native bed. These beds generally measure about as follows: Single native bed (*papag*), 165 cm long, 67 cm wide, 50 cm high. Double native bed, 185 cm long, 110 cm wide, 50 cm high.

According to studies by Nañagas and Santiago(25) the average height of male Filipinos is about 164 cm, and of females about 153 cm. Therefore, a net of 188 cm allows leeway for putting the arms above the head.

The 23 meters of sinamay netting would cost from 1.15 to 1.84 pesos,[1] as the price varies from 5 to 8 centavos per meter. It should be possible in most places to get the netting for 6 centavos per meter. It costs about 20 to 25 centavos to sew one net. Therefore, the total cost of a net would be from 1.35 to 2.09 pesos, depending on the cost of material and sewing. It is probably safe to say that the average cost of such a standard net as we recommend would be about 1.50 pesos.

Increasing the width of the net to 150 cm would make the dimensions suitable for two persons. Such a double net would require 28 meters of material, increasing the price of the net from 25 to 40 centavos. For persons sleeping on the floor the height could be decreased to 100 cm. When several persons sleep together on the floor, as is not uncommon in rural houses, a room net may be used. One measuring 350 by 250 by 100 cm can be made for 3.50 pesos.

The mesh of the sinamay should not count less than 16 or more than 20 in either direction per linear inch or 2.5 cm. The apertures should not be less than 1.15 mm or more than 1.5 mm in either dimension. The fiber should average about 0.328 mm.

## SUMMARY

This paper reviews the subject of mosquito nets, describes local sinamay netting made from abacá fiber, describes some experiments with various nettings as regards mosquito passage, wind passage, and comfort, and presents for the rural Philippines a possible standard mosquito bed net that would be

[1] One peso Philippine currency equals 100 centavos or 50 cents United States currency.

cheap, durable, made of local materials, and effective in malaria prophylaxis.

## CONCLUSIONS

1. Mosquito nets have certainly been used in the Philippines since 1640 and were probably used to some extent even prior to the Spanish era, which began in 1521.

2. The type of rural house in the Philippines is such that screening is not feasible. There is reason to believe that bed nets offer the most practical means at the disposal of the average householder for malaria prophylaxis.

3. The mesh of various kinds of netting must be measured in one of at least three different ways, depending on (*a*) whether the warp is or is not at right angles to the woof and (*b*) whether the holes are square or (*c*) rectangular. It would simplify matters considerably if mosquito netting were bought and experimented with on the basis of size of aperture.

4. The largest diameters of living, caught-wild anophelines of the *funestus-minimus* subgroup average as follows: *Anopheles filipinæ,* 1.14 mm; *A. mangyanus,* 1.19; *A. minimus* var. *flavirostris,* 1.13. Certain other species average as follows: *Anopheles barbirostris* (dead), 1.33 mm; *A. maculatus* (dead), 1.11; *Culex quinquefasciatus* (living), 1.72; *Aëdes ægypti* (living), 1.57.

5. Aëdes mosquitoes in passing through a net utilize the diagonal of an aperture. Having pushed head and one foreleg into the hole they hook the tibia of the protruding leg over a thread and pull the rest of their body through.

6. Locally made sinamay netting having a mesh of about 16 by 20, with fibers averaging 0.328 mm and apertures averaging 1.180 by 1.215 mm, will keep out all anophelines, all culicines, and most aëdines. It is a cheap, durable, and practical material for local mosquito nets. It will not admit as much wind as copper-wire screening of about the same size but is better than cotton netting in this respect.

7. Wind currents from an electric fan do not travel in a direct line but are swirling. To test the qualities of a screen as regards wind passage it is essential to straighten the wind currents, by using some such device as tunnels, in order to approximate the conditions prevailing when natural wind strikes a bed net.

8. As regards wind passage and comfort, wire screening is better than sinamay and sinamay is better than cotton netting.

9. Sinamay netting probably reduces comfort by not more than 25 per cent (in some tests as little as 14 per cent).

10. A standard mosquito net for the Philippines might have the following dimensions: Single, length, 188 cm; width, 100; height, 150. Double, length, 188 cm; width, 150; height, 150.

Such nets made of sinamay would cost about 1.50 and 1.75 pesos, respectively. They should be specially constructed for use where beds have no mattresses and where the people have no beds. The mesh should not be less than 16 or more than 20 apertures in either direction per linear inch or 2.5 cm, with apertures not less than 1.15 mm or greater than 1.5 mm in either direction. Fibers should average about 0.328 mm.

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# ILLUSTRATIONS

PLATE 1

FIG. 1. Abacá plants (*Musa textilis*). (Courtesy of the Bureau of Science.)
2. Weaving on a hand loom, Philippine Islands. (Courtesy of Dr. F. Vanoverbergh.)

PLATE 2

FIG. 1. A woman stripping abacá fibers. (Courtesy of the Bureau of Science.)
2. Weaving abacá sinamay on a hand loom, Alitagtag, Batangas.

PLATE 3

Philippine hand-woven netting; *a*, *b*, and *c* are all abacá sinamay; *d* is cotton. (Inch ruler.)

PLATE 4

Imported netting; *e* and *f* are English manufacture; *g* and *h* are Japanese manufacture; *e* has the usual 25/26 mesh for malaria prophylaxis. (Inch-ruler.)

PLATE 5

FIGS. *i* and *j*. Imported netting of Japanese manufacture. (Inch ruler.)
*k* and *l*. Imported netting of United States manufacture. Waxed cloth resembling wire.

PLATE 6

FIG. 1. Sinamay netting showing detail. In this sample the woof threads are double.
2. Diagram showing method of counting mesh when the woof is at an angle of 60° with the warp. Count holes *a* to *b* and add to holes *b* to *c*. Hole at *b* is to be counted twice. One square inch is shown. This sample counts 23.

PLATE 7

Cages for testing migration of mosquitoes through netting. Top cage for vertical migration, bottom cage for horizontal. Each cage has two compartments separated by the screen being tested. Only the first compartment in the lower cage is clearly shown in the photograph.

PLATE 8

Chimneys and cylinders used for testing migration of mosquitoes through netting.

PLATE 9

FIG. 1. Sinamay mosquito net inclosing single rural-style bed. The tunnels at bottom contain bamboo poles. The bottom of the net is tucked under this weight.

2. Sinamay mosquito net used on a double rural-style bed. The net is held in place by bamboo poles in tunnels as explained in the text.

PLATE 10

Detail of corner of bed and mosquito net, showing position of bamboo poles in the net tunnels under which the bottom of the net is tucked.

TEXT FIGURE

FIG. 1. Diagrammatic sketch showing line along which greatest diameter of mosquitoes was measured.

1

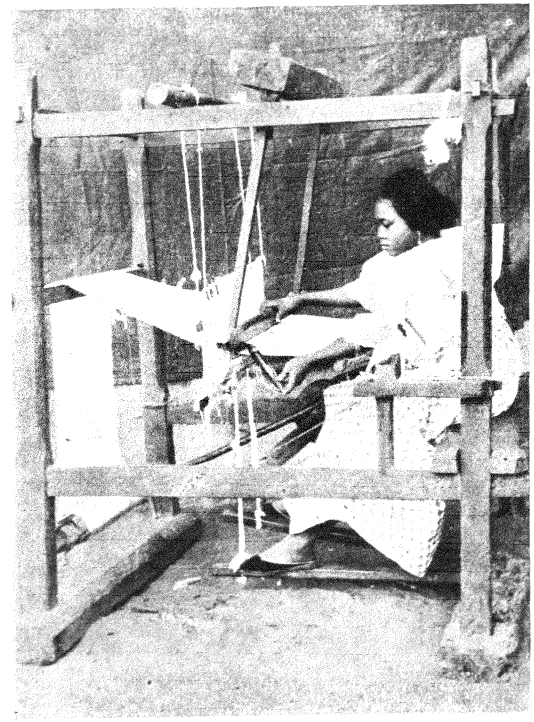

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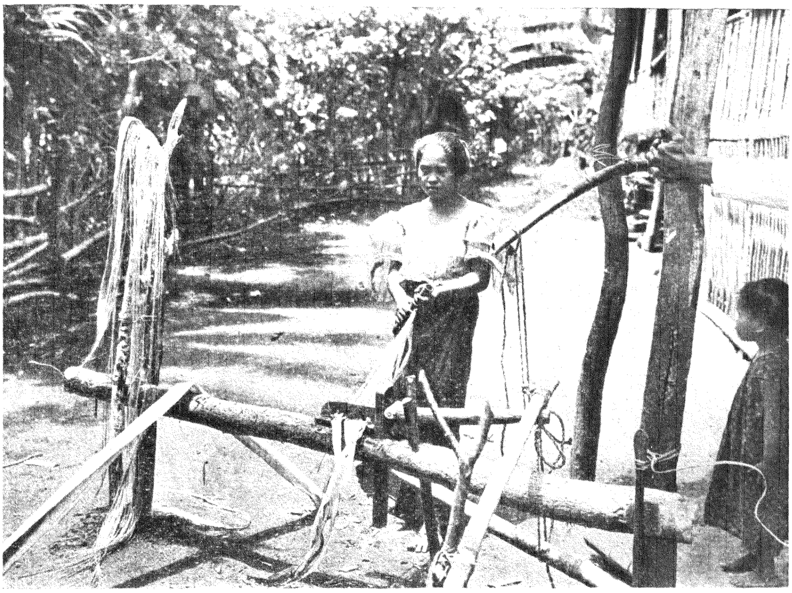
PLATE 1.



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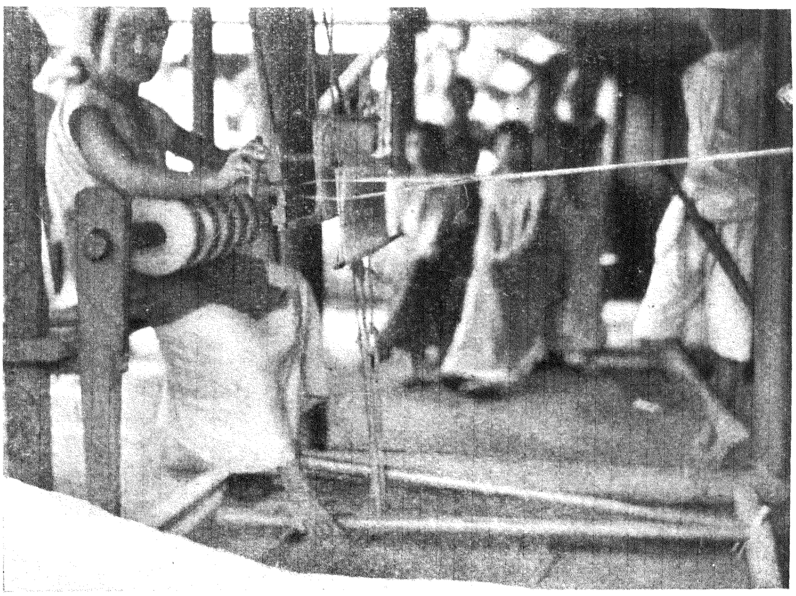

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PLATE 2.

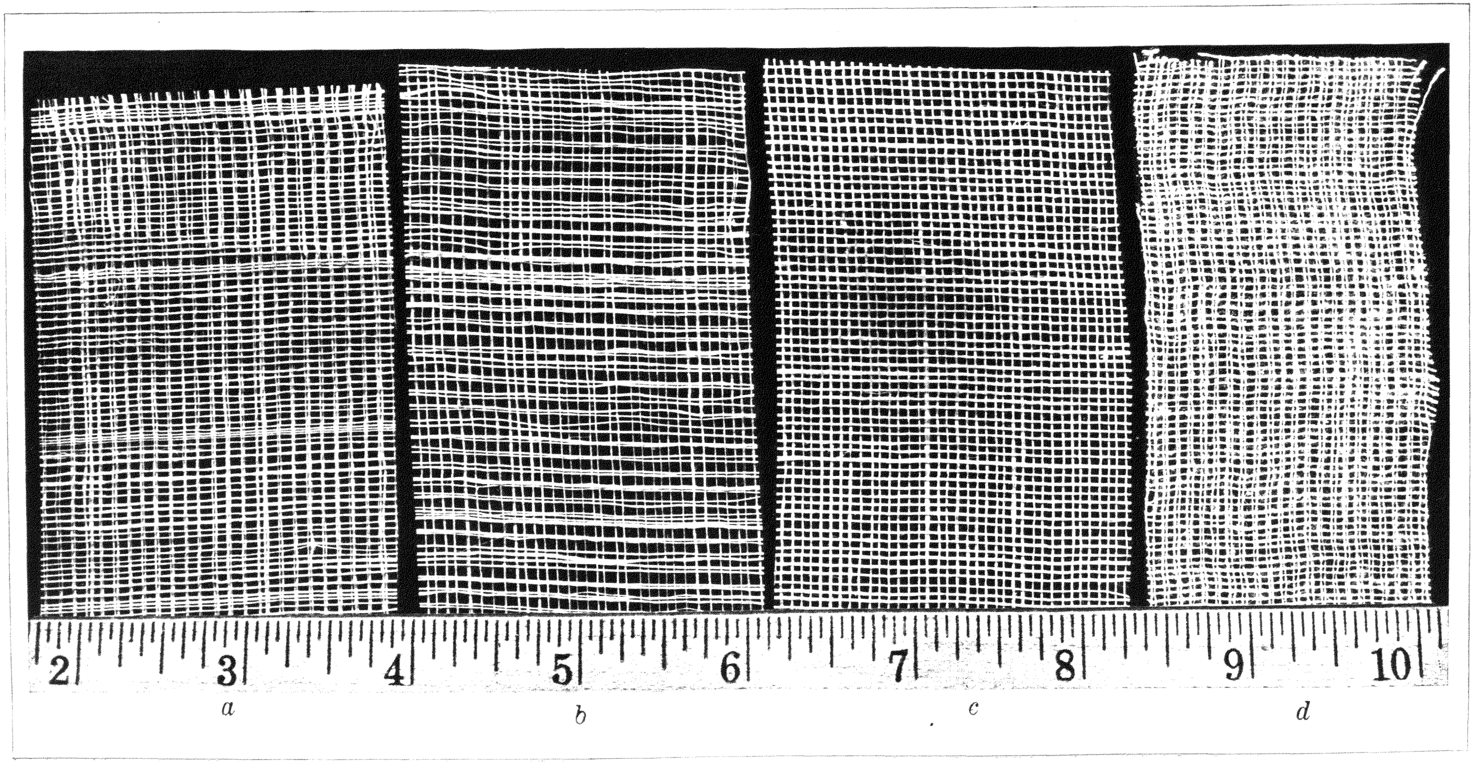
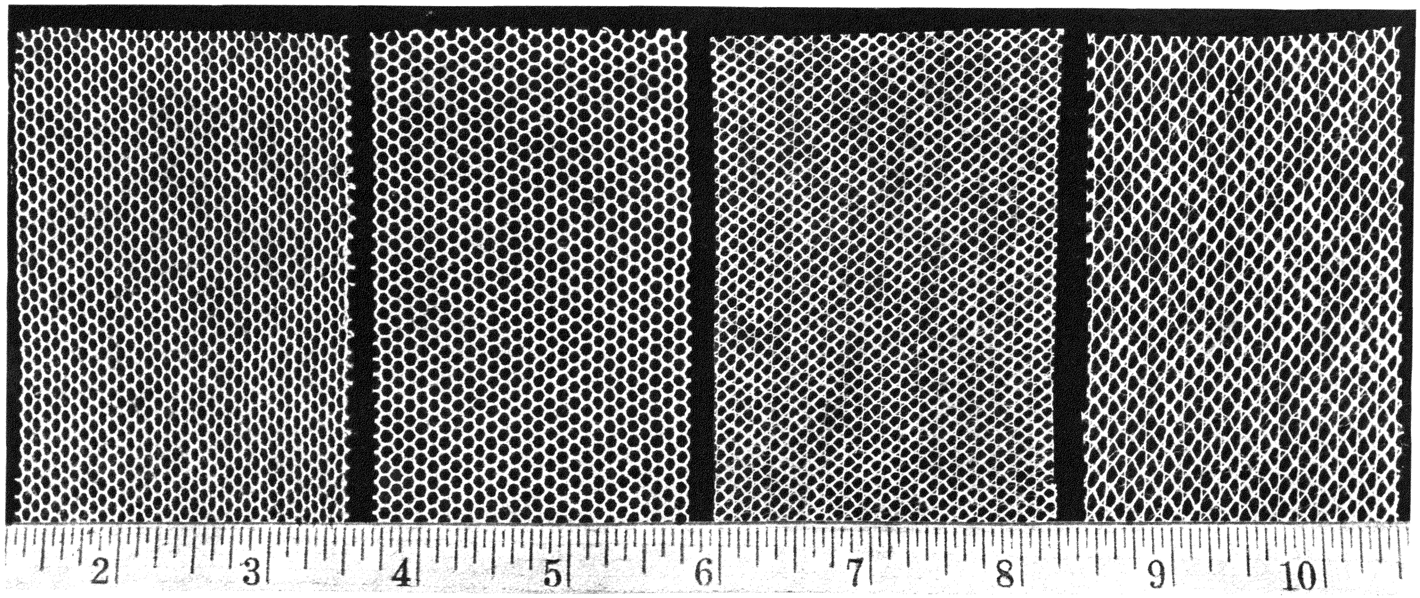
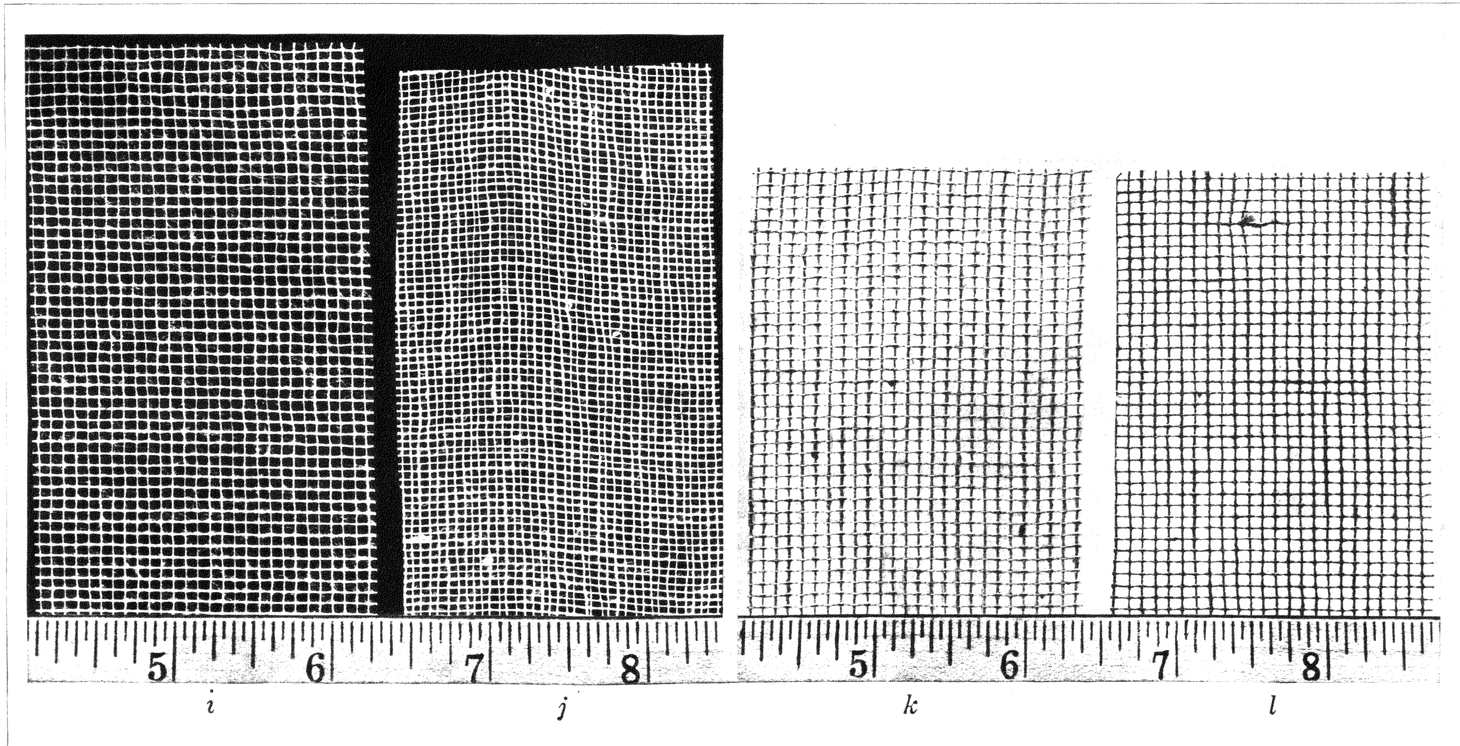



PLATE 3.




*e* *f* *g* *h*

PLATE 4.

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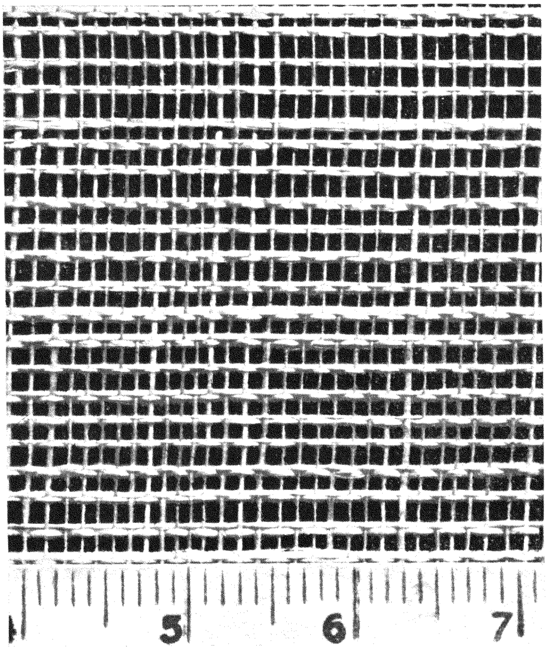


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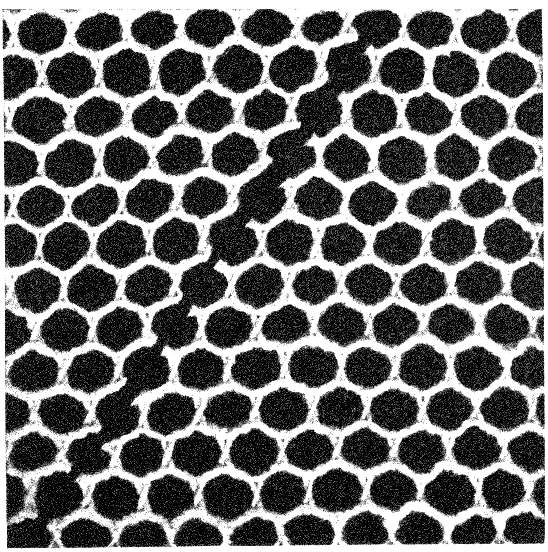

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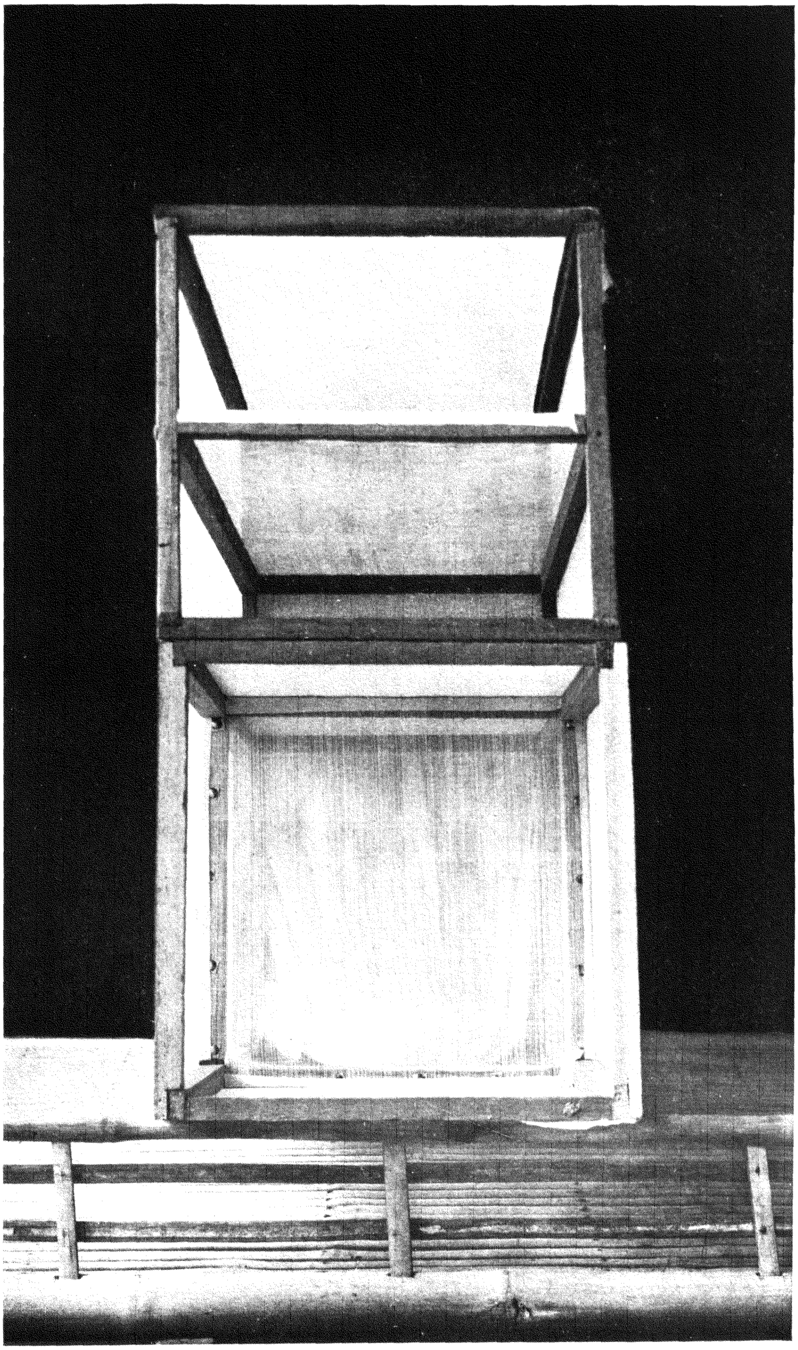
PLATE 6.



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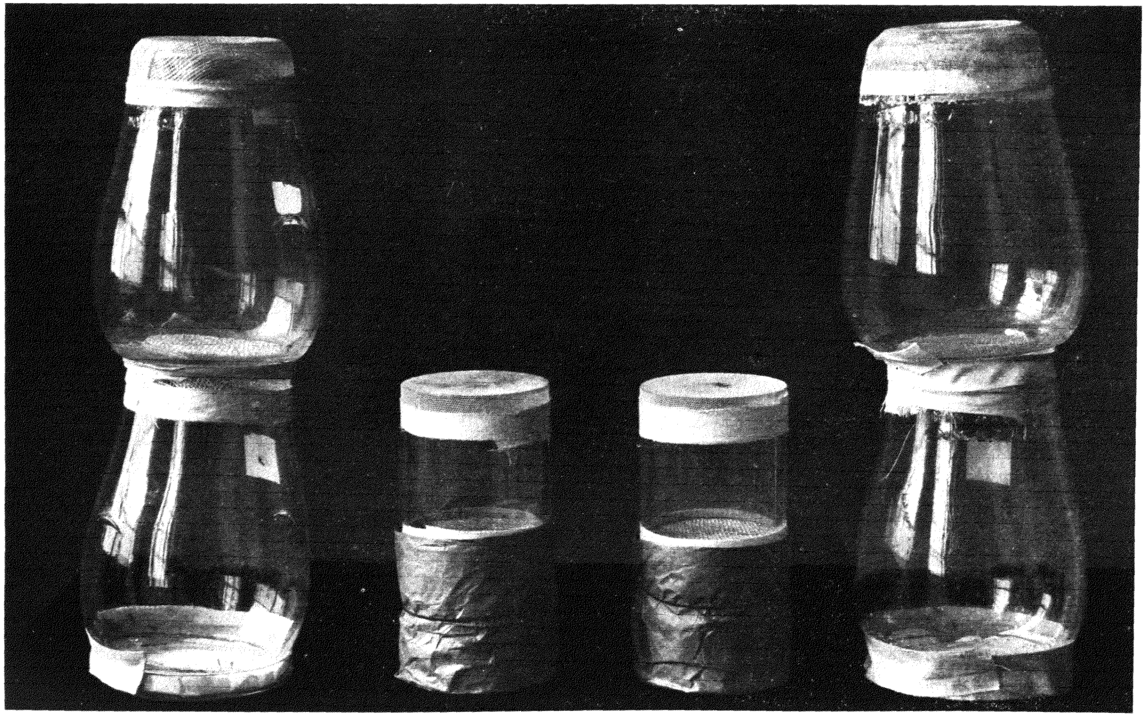

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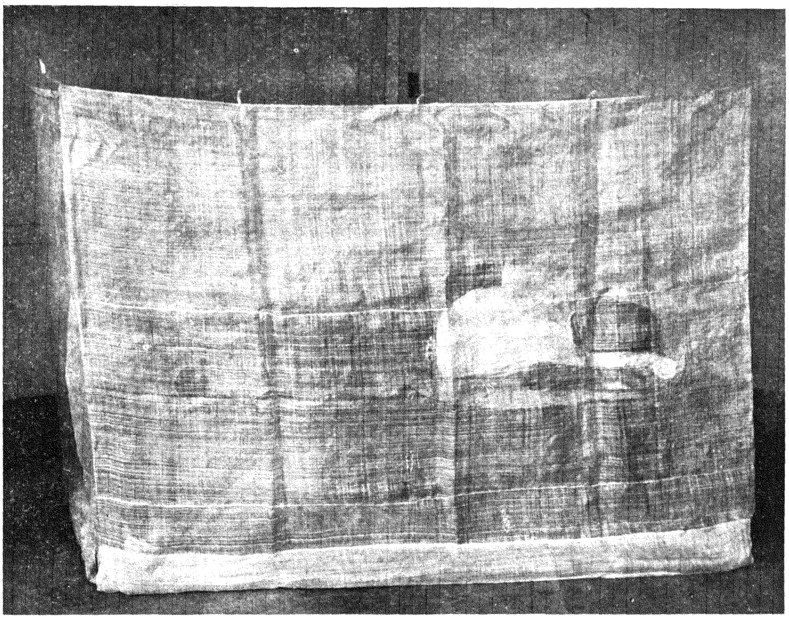

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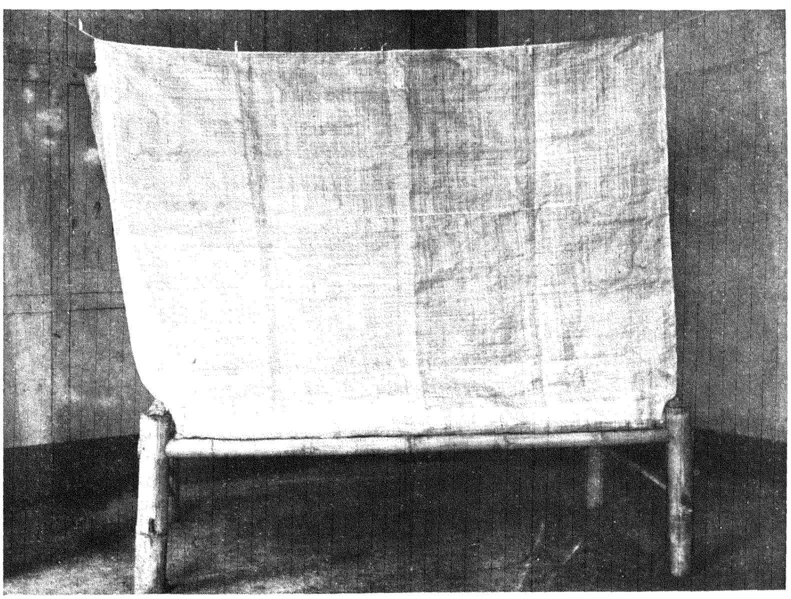

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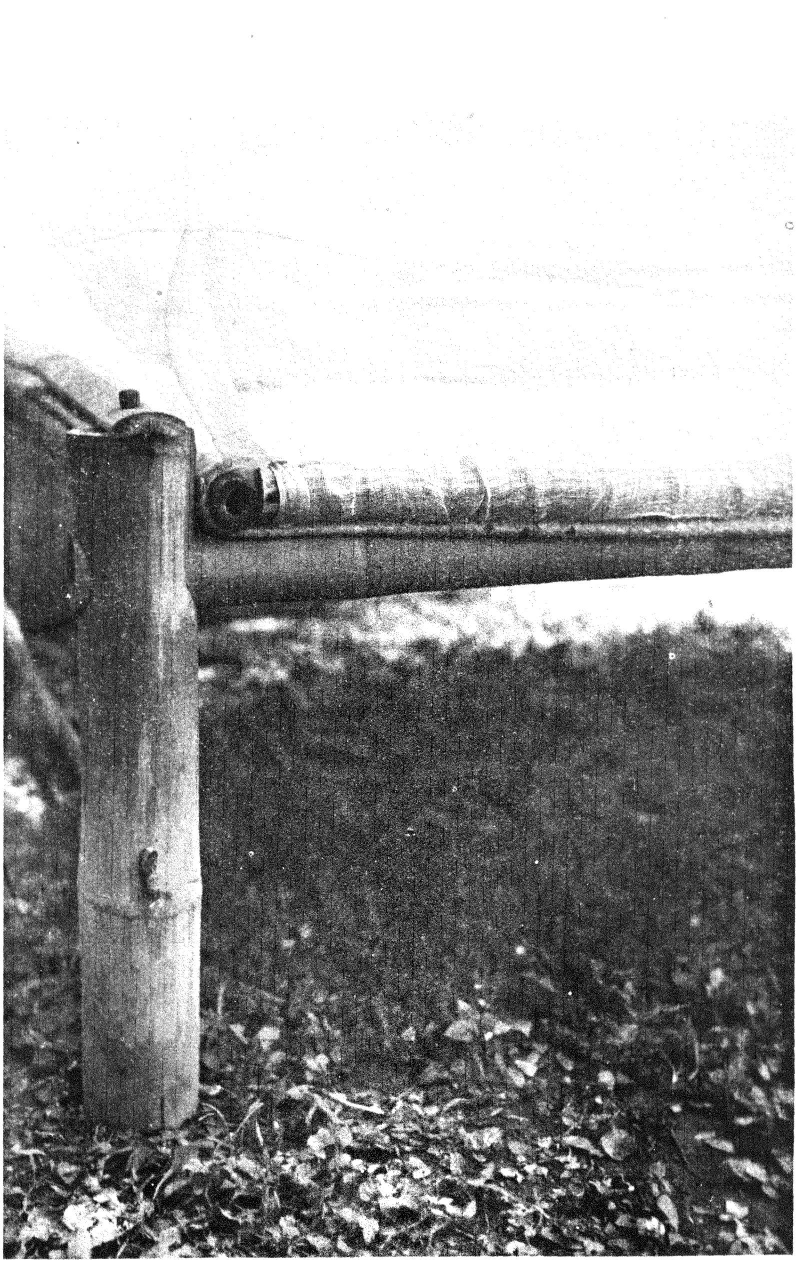

PLATE 10.

# OBSERVATIONS ON THE BONES OF NATIVE HORSES AFFECTED WITH OSTEOMALACIA

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FOUR PLATES AND TWO TEXT FIGURES

## INTRODUCTION

Osteomalacia, popularly known as osteoporosis or "bighead" among horse owners, is a disease of metabolism characterized principally by the softening and porosity of bones. Nothing definite is known of its etiology. Different theories have been advanced at various times, but for the sake of brevity no attempt will be made here to explain them further, for they have been thoroughly and critically discussed by Kintner and Holt(6) in their recent paper on this equine disease.

What condition or factor brings about pathologic changes in the bones has likewise been a subject of great speculation. According to Hess,(3) Virchow in 1853 advanced the theory that in osteomalacia the lesions are due to increased absorption of calcarous substance, and Pommer in 1885 claimed that they are brought about by decreased calcification. Hess also makes reference to von Ricklinghausen who was of the opinion that "halisteresis," bone dissolution, is the condition responsible for the changes, and to Schmorl and Looser who claimed that they are due to failure of calcification. Wells(13) and Hutyra and Marek(4) seem to support the theory of Virchow that increased absorption of lime salts from the calcified tissue causes the softening or brittleness and rarefication of bones.

A survey of the available literature on the subject revealed that only Koster,(7) Gonzalez and Villegas,(2) and Kintner and Holt(6) have written on osteomalacia in local animals, in spite of the fact that this equine malady is common among native Philippine as well as imported horses and that it is of tremendous economic importance. In fact, at present this is one of the most important diseases that seriously hamper the work of the Government in the improvement of the native stock.

The present paper reports the writer's findings with respect to the changes in the bones of ten cases of osteomalacia in native horses that came under his direct observation from time to time during the period from 1924 to 1932. The study was undertaken primarily to determine whether or not the disease under local conditions develops the same pathologic changes in the bones as those observed in cases reported in other countries, and to ascertain what possible relation the disease has to various types of lameness among horses. It is also hoped that the data reported herein will be of some interest to veterinarians who seek an explanation for the frequent occurrence of fractures in horses, even from apparently very insignificant causes.

## MATERIALS

Bones of ten native horses observed to be suffering from osteomalacia have been employed in the present study. In all the cases the bones of each individual animal were freed from other tissues, such as muscles, ligaments, fat, and bone marrow, by maceration. Two of the horses came from the hospital of the College of Veterinary Science, one was presented to the college by Mr. John Dumas, of Calauan, Laguna, three were used by the classes in surgical exercises, and four were obtained from the Department of Animal Husbandry, College of Agriculture. It might be mentioned here that the course and symptoms of the disease in the last four horses had been under the writer's observation ever since the first clinical symptoms were noted, and that, in addition, six other horses affected with this disease had been examined from time to time.

In order to facilitate the presentation and discussion of data herein recorded, the horses from the veterinary hospital are designated here as horses VH1 and VH2; that from Mr. Dumas, horse D3; those used by the classes in surgery, horses VS4, VS5, and VS6; and those from the animal-husbandry department, horses AH7, AH8, AH9, and AH10. A brief history of each animal, before it died or was sacrificed, follows:

*Horse VH1.*—Sex, stallion; color, bay; age, 5 years; height, 48 inches; use, carretela pony; place of origin, Los Baños, Laguna. This horse was an in-case in the Veterinary Hospital at one time, being treated for chronic nasal catarrh. After one week in the hospital the animal developed pneumonia from which he died about six or eight days later. When the animal was first brought in, he was also observed to be suffering from osteoporosis as indicated by the slight bulging of the face and moderately thickened lower jaw.

*Horse VH2.*—Sex, stallion; color, blood bay; age, 8 years; height, 49 inches; use, carromata pony; place of origin, Bay, Laguna. This animal was entered as a case of lameness due to bilateral spavin, but because of the fact that the animal did not respond favorably to the treatment given by the hospital, the owner finally decided to sell the animal to the College to be used by the Department of Anatomy for laboratory purposes. A thorough external examination performed by the writer before the animal was sacrificed, disclosed the following: The mandibular space was abnormally narrow due to the thickening of the rami of the mandible; there was palpated a nodular swelling at the medial aspect of the proximal third of the left metacarpus; slight elevation a little above the coronary region of the anterior limb; and swelling of the medial aspect of both hock joints.

*Horse D3.*—Sex, mare; color, dun; age, 6 years; height, 50 inches; use, for breeding; place of origin, Calauan, Laguna. The mare had been going lame in the posterior limb for some time before she was brought to the Veterinary Hospital for examination and treatment. She was found pregnant and suffering from some chronic hip trouble; the left gluteal region was already depressed due to the atrophy of the gluteal muscles. The condition being no longer amenable to treatment, the owner decided to donate the animal to the College for laboratory purposes. The only clinical symptom that led us to suspect that the mare was affected with osteomalacia consisted of slightly thickened and nodular lower jaw.

*Horse VS4.*—Sex, gelding; color, chestnut; age, 10 years; height, 48 inches; use, carromata pony; place of origin, Calamba, Laguna. This animal was bought by the College purposely for surgical exercises. He was lame in one of the posterior limbs. There was a slight swelling of the face. The mandible was somewhat thickened and the hock joints were slightly enlarged.

*Horse VS5.*—Sex, stallion; color, dark bay; age, 8 years; height, 49 inches; use, carromata pony; place of origin, San Pablo, Laguna. This animal presented a very typical picture of osteomalacia; the face was bulging and the lower jaw was very much thickened.

*Horse VS6.*—Sex, stallion; color, iron gray; age, 12 years; height, 48 inches; use, carromata pony; place of origin, Bay, Laguna. The only features observed in this animal indicative of osteomalacia consisted of the markedly thickened rami of the mandible and the enlargement of the hock joints.

*Horse AH7.*—Sex, stallion; color, cream; age, 17 years; height, 50 inches; use, for breeding; place of origin, College Campus, Los Baños, Laguna. This was one of the first stallions of the Department of Animal Husbandry, College of Agriculture. At about 8 years of age the animal suffered from time to time from an intermittent lameness in the hind limbs, apparently due to spavin. The animal had to be sacrificed because of the complete fracture of one of the anterior cannon bones, as a result of jumping on the manger.

*Horse AH8.*—Sex, mare; color, chestnut; age, 11 years; height, 50 inches; use, for breeding; place of origin, College Campus, Los Baños, Laguna. When this animal was about four years old, her head started bulging in the facial region. At the time she was sacrificed, because of the complete fracture of one of the femurs, her head was considerably enlarged.

The animal had also been suffering from lameness in the hind limbs from time to time.

*Horse AH9.*—Sex, mare; color, bay; age, 15 years; height, 49 inches; use, for breeding; place of origin, College Campus, Los Baños, Laguna. This animal was one of the first mares of the Animal Husbandry Department, College of Agriculture. She died of dystokia.

*Horse AH10.*—Sex, stallion; color, iron gray; age, 14 years; height, 53 inches; use, for breeding; place of origin, College Campus, Los Baños, Laguna. During life the only clinical symptoms that led us to believe that the animal was affected with osteomalacia consisted of the slight thickening of the lower jaw. Paraplegia, induced by osteoporosis, and found to be due to the compression of the lumbar components of the lumbo-sacral plexus by exostoses in the lumbar vertebræ, was the immediate cause of death according to the report by San Agustin.(12)

TABLE 1.—*Showing the average weights of bones of the affected and control animals.*

| Bones. | Average weight. | | Excess in favor of control. | Difference. |
|---|---|---|---|---|
| | Osteomalacic. | Control. | | |
| | *g.* | *g.* | *g.* | *Per cent.* |
| Skull (with mandible) | 2,322.3 | 2,786.1 | 462.8 | 16.6 |
| Fourth cervical vertebra | 94 | 130.0 | 36.0 | 27.8 |
| Ninth thoracic vertebra | 29.5 | 46.9 | 17.4 | 37.1 |
| Third lumbar vertebra | 42.8 | 62.9 | 20.1 | 31.9 |
| Sacrum | 115.6 | 168.8 | 53.2 | 31.5 |
| Ninth rib | 41.9 | 59.1 | 10.2 | 19.5 |
| Scapula | 234.3 | 310.6 | 76.3 | 24.5 |
| Humerus | 438.0 | 502.2 | 64.2 | 12.7 |
| Radius and ulna | 414.7 | 481.4 | 66.7 | 13.8 |
| Third metacarpal | 155.6 | 217.6 | 62.0 | 28.4 |
| First phalanx (anterior limb) | 61.1 | 67.1 | 6.0 | 8.9 |
| Ossa coxarum | 735.8 | 867.6 | 131.8 | 15.1 |
| Femur | 621.0 | 717.3 | 96.3 | 13.4 |
| Tibia | 422.6 | 512.4 | 89.8 | 17.5 |
| Third metacarpal | 212.7 | 259.7 | 47.0 | 18.0 |
| First phalanx (posterior limb) | 57.8 | 62.1 | 4.3 | 6.9 |

## WEIGHT OF THE BONES

After the bones of each horse had been perfectly macerated and dried, the weights of the skull, the long and flat bones from both anterior and posterior extremities, one representative from each region of the vertebral column, except the coccygeal, and from the ribs, were determined and compared with those of the normal animals. This was undertaken for the purpose of gaining some information concerning the effect of the disease upon the weights of the bones. In the selection of bones from a normal animal as control, care was taken to use bones from an

animal of practically the same age and height as the one under study. The nature of the teeth was used in the determination of age, and the length of the long bones of the extremities was used as a criterion for comparing height. In Table 1 the average weights of the various bones of the osteomalacic and the control animals are compared and the percentages of difference given.

As may be noticed from Table 1 the bones of the osteomalacic animals are invariably lighter than the corresponding bones of the control. The difference, however, is not at all uniform in the same bones in different animals nor in various bones in the same animal. It seems, however, that the bones of the vertebral column and the flat bones are in general the worst affected in the decrease in weight, and that the decrease is dependent upon the pathologic lesions in the bones. It is interesting to note also that even the abnormally enlarged skulls in some cases were much diminished in weight.

## ANATOMICAL CHANGES IN THE BONES

The macerated bones of each osteomalacic animal were carefully examined. The following is the record of the individual animal:

*Horse VH1.*—The face was slightly bulging. There was a marked porosity of the outer cortex of the bones of both face and the cranium, especially the frontal and maxillæ. Attached to the surface of the bones were thin plates of bony tissue which were scalelike and could be easily peeled off. The maxillary tuberosity was very much enlarged and brittle. The ventral border of the rami of the mandible was nodular and slightly thickened; porosity was relatively marked in the nodular parts. Throughout the vertebral column the rarefication of the outer cortex of the bones was very manifest. This was also true in the case of the ribs. Other than the porosity of the scapulae, the pelvic bones, and the tuberosities and other eminences of the long bones, the bones of the thoracic and pelvic limbs showed no particular features.

*Horse VH2.*—The rami of the mandible were abnormally thick, especially along the ventral border. There was a generalized porosity of the bones of the head, in spite of the absence of the swelling of the face. Scalelike pieces of bones were abundant. The vertebræ, the ribs, and the flat bones of the anterior and posterior limbs were likewise porous. The compact substance of the long bones of the extremities seemed to be not very much affected, the porosity being confined in the eminences. The second and the third metacarpal bones on the left side were completely fused, and at their proximal third there was an exostosis. The distal extremity of one of the first phalanges and the proximal part of one of the second phalanges presented in front irregular bony growth. The tarsal bones, with the exception of the tibial and fibular, were consolidated in both sides and were fused with the metatarsal bones.

*Horse D3.*—There was a slight porosity of the bones of the skull and the rami of the mandible were abnormally thick along the ventral border. With the exception of the presence of exostosis in the lateral aspect of the superior ischiatic spine and the adjacent part of the shaft of the ilium and the lateral margin of the acetabulum, the rest of the bones of this animal appeared to be normal.

*Horse VS4.*—Other than the presence of exostosis in the proximal part of the anteromedial aspect of the large metatarsal bones in both sides, the bone lesions presented by this case were practically similar to those of horse VH1.

*Horse VS5.*—There was a moderate swelling of the face. Marked porosity was observed throughout the skull. The intermandibular space was narrow due to the thickened rami of the mandible. The ribs and vertebræ showed only slight porosity, and the bones of the extremities appeared to be not yet affected.

*Horse VS6.*—In spite of the absence of the swelling of the face and marked deformity of the mandible, the bones of this animal, including the long bones of the limbs, were all badly affected, the rarefication being relatively severe in the bones of the face, vertebral column, ribs, and flat bones of the limbs. Exostosis was present in the anteromedial aspect of the proximal extremities of both large metatarsal bones.

*Horse AH7.*—The size of the skull was apparently normal, no deformity being observed except the moderately thickened rami of the mandible. All the bones of the face and cranium were very porous and rough and there were plenty of small indentations. The lesions were most salient along the ventral borders of the rami of the mandible, in the crests which limit the temporal fossa, and in the supraorbital and coronoid processes and the zygomatic arches. The free end of the nasal bones was very brittle. The bones of the vertebral column and the ribs were almost spongy in nature. The spinous processes of most of the thoracic and lumbar vertebræ and the sacrum were very much thickened and deformed. The fifth and sixth lumbar vertebræ were consolidated. The last four pairs of ribs were abnormally twisted and they were studded with irregular eminences or tubercles on their costal surface. All the bones of the anterior and posterior limbs also showed marked porosity, though they were not uniformly affected. The large metacarpals were bowed, and the fourth and central, the third and the first and second tarsals in both limbs were completely fused.

*Horse AH8.*—Of all the cases studied this animal was worst affected. The skull was considerably deformed, having a very pronounced external swelling of the maxillary, malar, and lacrimal bones, and abnormally thickened rami of the mandible. All bones of the face and cranium were fragile and could easily be crushed into powder, even with the fingers. The external surface of the bones presented numerous irregular depressions. The nasal cavity was narrow and the infraorbital foramen as well as the mental foramen was somewhat obliterated. The intermandibular space was very narrow and the swelling of the rami of the mandible was much more pronounced along the alveolar border than along the ventral border. All the alveolar cavities of both the upper and the lower jaws were very much widened. The ribs and the vertebræ were weak and fragile and almost spongy in character. All the bones of both the

anterior and the posterior limbs were conspicuously porous, especially the scapulæ, the pelvic bones, the humerus, and the femurs. Both radii were abnormally bowed. The first phalanges of the anterior limbs presented exostosis on either side midway between the proximal and distal extremities. With the exception of the tibial and fibular tarsal bones all the bones of the tarsus on both sides were fused.

*Horse AH9.*—There was no enlargement of the face, but all the bones of the skull were weak and porous. The external surface of the maxillary bones presented numerous irregularly excavated areas. The nasal bones were almost transparent. The mandible presented only a slight swelling along the alveolar border of the rami. All the teeth were very loose because of the enlarged alveolar cavities. The vertebræ in all the regions of the vertebral column as well as the ribs were almost spongy in nature. The bones of both the anterior and posterior limbs seemed to be not very much affected, showing only slight porosity of the external cortex.

*Horse AH10.*—There was a generalized porosity of the skull. The mandible was slightly thickened and was characterized by the presence of bony protuberances on the lateral surface of the alveolar border of the rami. The mental foramen was somewhat obliterated and overhung by exostoses. The ribs and the bones of the vertebral column were all porous and weak; the spinous processes of the thoracic and lumbar vertebræ were more or less spongy in nature. On the ventral surface of the bodies of the third, fourth, and fifth lumbar vertebræ large exostoses were found, practically obliterated the intervertebral foramina formed by these vertebræ. The bones of the anterior and posterior extremities likewise showed marked porosity. The tuber scapulæ and the coronoid processes were abnormally large and irregular because of the presence of exostosis. The large and small metacarpals in both limbs were completely fused. There was also exostosis in the proximal part of the dorsal surface of the first phalanx of one of the anterior limbs, and on the lateral surface of the right superior ischiatic spine just a little above the rim of the acetabulum. The central and the third tarsal bones were consolidated; and the fourth and the fused first and second tarsal bones were very much enlarged and deformed because of the presence of exostosis.

Based on the summary of the various features observed in the skeletons of the animals studied, it may be inferred that in general the anatomical changes in the bones of native horses suffering from osteomalacia are similar to those described by other investigators. It seems also safe to state here that neither the breed of animal nor the environmental conditions—climatic or otherwise—have any influence upon the macroscopic picture of the bones of animal affected with this disease.

Kintner and Holt (6) say that in imported army horses and mules in the Philippines "all the bones of the skeleton are involved in the process, and that the variation in the degree of severity is due, probably, to external influences, such as mechanical irritation, etc." The present study, however, inclines the writer to believe that, although all the bones are involved, the

rarefication of the external cortex does not occur throughout the bones of the skeleton at the same time. In the incipient stage of the disease the gross changes are invariably confined to the bones of the skull, and only in severe cases do the long bones of the extremities show external lesions. This condition may be accounted for by the fact that, according to Friedberger and Frohner,(1) the decalcification of bones starts from within outward. Thus, it is but natural to expect that bones having thin cortex or compact substance should suffer first. Careful study of the bones of incipient or mild cases, moderate cases, and severe cases has convinced the writer that rarefication of bones in osteomalacia manifests itself externally in the following order: (*a*) Skull, (*b*) vertebræ and ribs, (*c*) flat bones of the extremities, like scapula and os coxæ, and (*d*) long bones of the extremities.

The bilateral enlargement or bulging of the skull in the region of the face is not always a constant feature in osteomalacia. The writer has observed that such deformity of the skull develops only when the animal becomes affected with the disease while still young. Niimi(10) also seems to attribute the slightness of the swelling of the facial bones of the horses he used in his experimental studies on osteomalacia to old age. Other deformities of the skeleton, like exostosis, abnormal bending of long bones and ribs, fusion of the vertebræ and the tarsal bones, etc., are only secondary in nature, and they are probably due to external influences such as blows, kicks, and other forms of mechanical irritation. It has been observed that, except for the enlargement of the skull in some cases, the size of the rest of the bones of the skeleton was not affected by the disease, even in very severe cases where the gross lesions were generalized, and that in severe cases the medullary cavity of the long bones was invariably enlarged.

Because of the common occurrence of exostoses and other skeletal deformities in affected animals, the origin and cause of certain types of lameness among horses may be traced to osteomalacia. In the majority of the cases that the writer has observed, lameness in either the fore or hind limbs constituted the commonest complaint.

## HISTOLOGY OF THE COMPACT SUBSTANCE OF LONG BONES

To determine what effect the disease has upon the lamellar systems of the compact substance of osseous tissue, several transversely ground sections from the middle of the shaft of the

large metacarpal of horse AH7 and the femur of horse AH8 were prepared and mounted in balsam. It may be mentioned

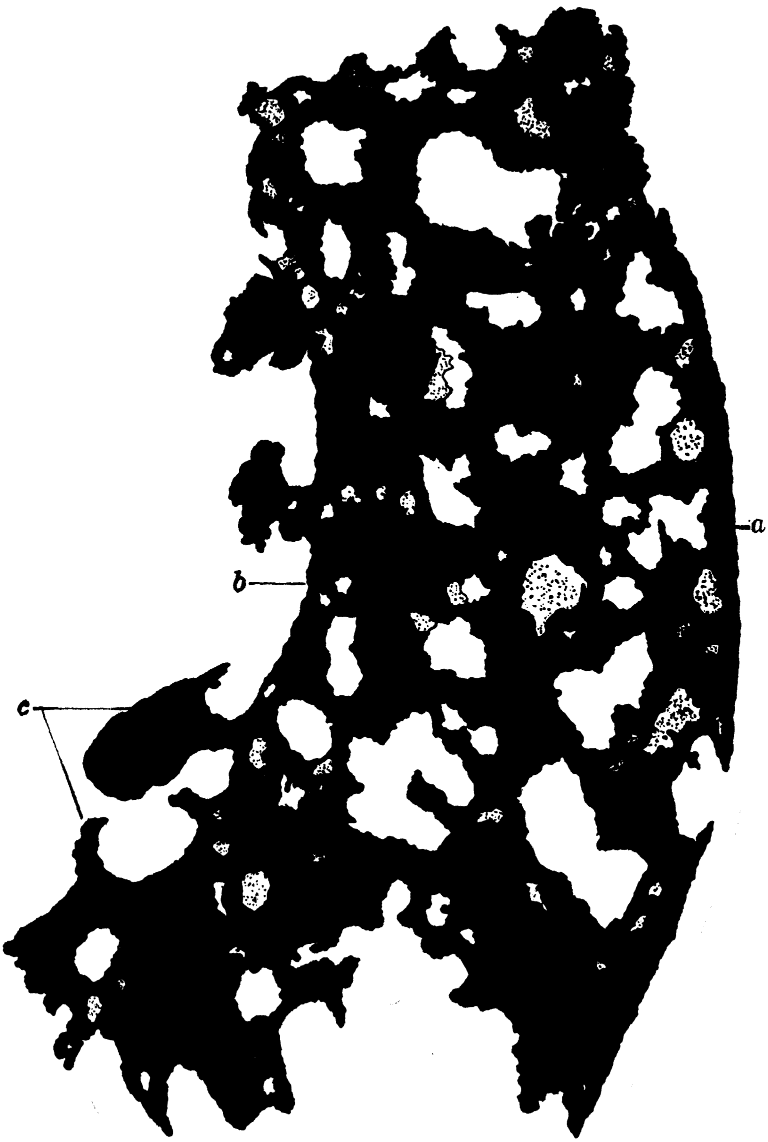


FIG. 1. Segment of transversely ground section through the middle of shaft of the femur of horse AH8 as seen under Spencer dissecting microscope No. 80. Stained black with silver nitrate solution. *a*, Outer, or periosteal, surface; *b*, inner, or medullary, surface; *c*, bits of bony tissue.

here that the bones of these animals were selected because, besides having generalized gross changes, they were the ones

sacrificed due to complete fracture of the said bones. Similar sections were also prepared from the same bones of their respective control. Some of the sections were stained with 1 per cent silver nitrate solution.

Careful comparative study under the microscope of both the sections of osteomalacic specimens and those prepared from the same bones of the control animals disclosed the following features: The thickness of the compact substance of the shaft of long bones studied has been greatly diminished; presence of numerous irregular bits of bony tissue (fig. 1) attached to the inner or medullary surface; presence of erosions and small excavations on the external or periosteal surface; both the periosteal lamellæ and the endosteal lamellæ have been considerably decreased in thickness and in some places they are totally absent; and most of the Haversian canals, which appear in the sections as irregular empty spaces of different sizes (fig. 2), have been amply enlarged, and the surrounding concentric lamellæ, in many places, are no longer present. Very likely many of the large spaces have been due to the coalescence of the adjacent enlarged Haversian canals. With this microscopic picture of the changes in the lamellar systems it may be assumed that the destructive elements of the calcarous tissue—osteoclasts or otherwise—in the compact substance of the long bones are mostly lodged in the Haversian canals.

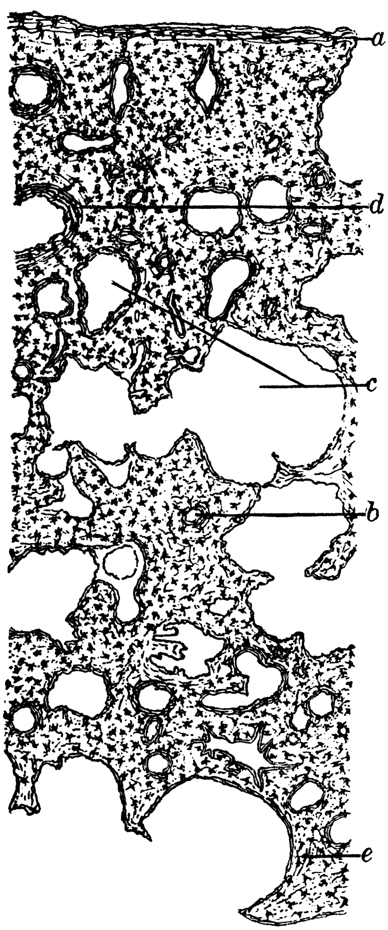


FIG. 2. Segment of transversely ground section through the middle of the large metacarpal bone of horse AH7, drawn under Reichart microscope with ocular No. 1 (13x) and objective No. 3 (10x). *a*, Outer circumferential, or periosteal, lamellæ; *b*, normal Haversian canal; *c*, enlarged Haversian canals; *d*, concentric lamellæ; *e*, inner circumferential, or endosteal, lamellæ.

## BREAKING STRENGTH OF LONG BONES

Comparative tests were conducted to determine the weights required to cause fracture in different long bones of the normal and the osteomalacic animals. The Tinus Olsen testing machine of the Bureau of Science was employed in the tests. Each specimen was arranged in such a way that the span between its stationary supports was exactly 15 centimeters and that the mechanical weight was gradually applied midway between the supports.

TABLE 2.—*Showing the average weights required to cause fracture in the long bones of control and osteomalacic animals.*

| Name of bone. | Control. | Osteomalacic. | Excess in favor of control. | Difference. |
|---|---|---|---|---|
| | *kg.* | *kg.* | *kg.* | *Per cent.* |
| Humerus | 1,702 | 1,170 | 532 | 31 |
| Radius | 2,032 | 1,505 | 527 | 25 |
| Large metacarpal | 1,777 | 1,237 | 540 | 29 |
| First phalanx | 5,750 | 2,285 | 3,465 | 60 |
| Femur | 1,640 | 1,375 | 265 | 16 |
| Tibia | 2,620 | 1,502 | 1,118 | 42 |
| Large metatarsal | 2,610 | 1,647 | 963 | 36 |
| Ninth rib | 200 | 120 | 78 | 39 |

As may be noted from Table 2 this experiment demonstrated that the weights required to cause fracture in various long bones of both the normal and the osteomalacic native horses vary with the kind of bone, and that under the same conditions bones from horses affected with osteomalacic fracture under less weight than do bones from normal animals. In the last column of the table are given the average percentages of the difference, and, as may be noticed here, the percentages vary in different bones.

## CHANGES IN THE CHEMICAL COMPOSITION OF BONES

Available data concerning the chemical changes occurring in the bones of horses affected with osteomalacia are not at all uniform. According to Friedberger and Frohner(1) the lime content of osteomalacic bones is reduced more than one-half and the water content increased. McCrudden(8) observed a decrease in calcium and phosphorus and an increase in magnesium and sulphur in the ribs of two horses affected with the disease. Mohler(9) claims that bones of osteomalacic animals contain less fat, phosphoric acid, lime, and soda and more organic matter

and silicic acid. Ingle,(5) in his comparative analysis of the bones of diseased and normal horses, mules, and donkeys, found little difference in the composition of bones of osteomalacic animals as compared with those of the normal ones, and in normal bones he observed larger proportions of ash, lime, and phosphoric acid. Kintner and Holt(6) state that there is a reduction of the total mineral content in the bones of affected animals, and that the percentage of calcium and phosphorus in the bone ash of the affected animals is approximately the same as in the normal ones, but the magnesium content is much increased. Niimi and Aoki,(11) in their chemical analysis of the ribs of osteomalacic cases produced experimentally, also did not obtain uniform results. In one group of horses they found a reduction in water and an increase in calcium and phosphoric acid, and in another group there was more water and less ash. The quantity of magnesium also was not the same in the two groups.

TABLE 3.—*Showing the average percentages of the chemical constituents of dried macerated bones from osteomalacic and normal horses.*

| Bones. | Subject. | Moisture ($H_2O$). | Fat. | Phosphate of lime ($Ca_3(Po_4)_2$. | Carbonate of lime ($CaCo_3$). | Phosphate of magnesia ($Mg_3Po_4)_2$. | Carbonate of sodium ($Na_2Co_3$). | Chloride of sodium (NaCl). |
|---|---|---|---|---|---|---|---|---|
| | | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* | *P. ct.* |
| Humerus | Control | 7.34 | 0.55 | 31.91 | 6.92 | 2.16 | 7.34 | 0.10 |
| Do | Affected | 8.70 | 1.68 | 41.66 | 4.72 | 2.68 | 4.79 | 0.15 |
| Radius and ulna | Control | 7.44 | 0.93 | 44.81 | 8.37 | 3.74 | 8.86 | 0.45 |
| Do | Affected | 7.50 | 0.81 | 47.22 | 6.71 | 2.51 | 7.11 | 0.36 |
| Metacarpal | Control | 7.39 | 0.99 | 31.00 | 7.43 | 2.13 | 7.86 | 0.44 |
| Do | Affected | 8.34 | 1.34 | 32.02 | 4.28 | 2.36 | 4.48 | 0.16 |
| Femur | Control | 7.63 | 1.14 | 42.89 | 8.04 | 1.08 | 8.78 | 0.18 |
| Do | Affected | 6.91 | 1.26 | 38.31 | 5.90 | 2.82 | 6.25 | 0.20 |
| Tibia | Control | 8.23 | 0.53 | 25.63 | 10.55 | 5.10 | 11.18 | 0.27 |
| Do | Affected | 7.41 | 1.39 | 21.32 | 7.12 | 1.65 | 7.48 | 0.05 |
| Metatarsal | Control | 8.71 | 0.83 | 24.64 | 8.39 | 2.97 | 8.90 | 0.05 |
| Do | Affected | 8.49 | 1.16 | 39.18 | 6.10 | 2.27 | 6.46 | 0.32 |
| Vertebræ | Control | 7.64 | 1.83 | 41.10 | 10.04 | 2.13 | 10.49 | 0.06 |
| Do | Affected | 8.43 | 0.73 | 25.18 | 6.99 | 1.73 | 7.41 | 0.42 |
| Ribs | Control | 8.09 | 1.54 | 38.81 | 7.29 | 3.42 | 11.20 | 0.37 |
| Do | Affected | 7.98 | 0.93 | 32.15 | 5.72 | 3.11 | 6.07 | 0.34 |
| Total average | Control | 7.80 | 1.04 | 35.09 | 8.37 | 2.84 | 9.32 | 0.24 |
| Do | Affected | 7.98 | 1.03 | 34.63 | 5.94 | 2.39 | 6.25 | 0.25 |

In order to gain some information concerning the changes in the chemical composition of bones of native horses affected with

osteomalacia, chemical analysis * of bones from affected and normal animals was undertaken. Samples for anlysis were prepared from different bones by filing with a rasp.

The analyses in Table 3 show that the different chemical constituents of dried macerated bones from normal as well as from osteomalacic native horses vary in different bones, and that an osteomalacic specimen is not always deficient in certain chemical elements, as compared with the corresponding specimen from a normal animal.

The percentage of moisture and fat is approximately the same for osteomalacic as for normal bones. The figures given here, of course, do not represent the total percentage of these elements in fresh bones. The total average percentages obtained for the different principal inorganic constituents of bones are as follows: For normal bones, phosphate of lime, 35.09; carbonate of lime, 8.37; phosphate of magnesium, 2.84; carbonate of sodium, 9.32; and chloride of sodium, 0.24. For osteomalacic bones, phosphate of lime, 34.63; carbonate of lime, 5.94; carbonate of sodium, 6.25; and chloride of sodium, 0.25.

The average percentage obtained for the total inorganic constituents of bones is 55.86 for normal horses and 49.46 for osteomalacic animals, a difference of 6.40. This clearly shows that there is also a reduction of the total mineral content in the bones of native horses affected with osteomalacia; the reduction is principally noticed in the carbonate of lime, phosphate of lime, and carbonate of sodium. The phosphate of magnesium is slightly increased, but the chloride of sodium is practically the same as in normal bones.

## SUMMARY AND CONCLUSIONS

1. Dried macerated bones of seven male and three female native Philippine horses affected with osteomalacia, ranging in age from 5 to 17 years, were used in the present study. For comparative purposes bones of normal native horses were also included in this investigation.

2. Comparative study of bones of osteomalacic and normal horses has demonstrated that the weight of bones of affected animals is invariably much diminished. The percentage of dif-

* The chemical analyses of bones were made possible through the courtesy of the Department of Chemistry, College of Agriculture, University of the Philippines. Grateful acknowledgment is made here to the members of the department, particularly to Mr. L. Yñalvez, who made the analyses, for their very valuable and kind coöperation.

ference, however, varies not only in different animals but also in different bones of the same animal, depending upon the severity of the gross lesions in the bones.

3. The macroscopic picture of the gross anatomical changes in the bones of native horses suffering from osteomalacia fairly agrees with what has been previously described by other investigators. Environmental conditions and breed of animals seem to play no rôle in the anatomical changes of the diseased bones.

4. It has been observed that rarefication of the cortex or compact substances of bones does not occur throughout the bones of the skeleton at the same time, but is confined to the bones of the skull in the incipient stage; other bones, especially those of the extremities, are affected only in severe cases.

5. The bilateral swelling of the skull in the region of the maxillary, lacrimal, and malar bones has not been noted as a constant feature in horses affected with osteomalacia. The results of the present investigation prompt the writer to believe that animals already advanced in age when affected with this disease, do not develop such a deformity. The mandible on the other hand has been observed in all cases studied to have increased in thickness in varying degree, either along the ventral or the alveolar border of the rami. In no case have the rest of the bones of the skeleton been found to have changed in size, except where exostoses were present.

6. The thickness of the compact substance of the shaft of the long bones of affected animals is much diminished. This condition may be accounted for by the destruction of the inner and the outer circumferential lamellæ. The Haversian canals are very much enlarged and the concentric lamellæ surrounding them are totally absent in many places.

7. Bones from osteomalacic horses have been found to require less weight to fracture them than bones from normal animals. The required weights, however, vary in different animals and in different bones of the same animal.

8. A reduction of the total mineral content has also been observed in the bones of native horses affected with osteomalacia. An average of 55.86 per cent for normal horses and 49.46 per cent for affected animals has been found to constitute the total inorganic constituent. The reduction was noted particularly in carbonate of lime, phosphate of lime, and carbonate of sodium.

9. Many cases of lameness among horses, especially those of obscure origin, may be attributed to osteomalacia, exostoses,

anchyloses, and other skeletal defects very common in the bones of animals affected with this disease.

10. The frequent occurrence of fractures in osteomalacic animals, even from very insignificant causes, must be due to the decrease in strength of the bones because of the diminished thickness and the porosity of the compact substance.

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# ILLUSTRATIONS

### Plate 1

Fig. 1. A case of osteomalacia in native horse AH8, showing the typical bilateral swelling of the face.

Figs. 2 and 3. Skull of an osteomalacic horse at incipient stage. Note the erosions on the surface of the skull and the nodular thickenings of the ventral borders of the rami of the mandible.

### Plate 2

Some bones of a very severe case of osteomalacia (horse AH7), showing no bulging of the face and generalized porosity.

### Plate 3

Dorsal view of the skull and ventral view of the mandible of horse AH8. Note the marked swelling of the face and the abnormally thickened rami of the mandible.

### Plate 4

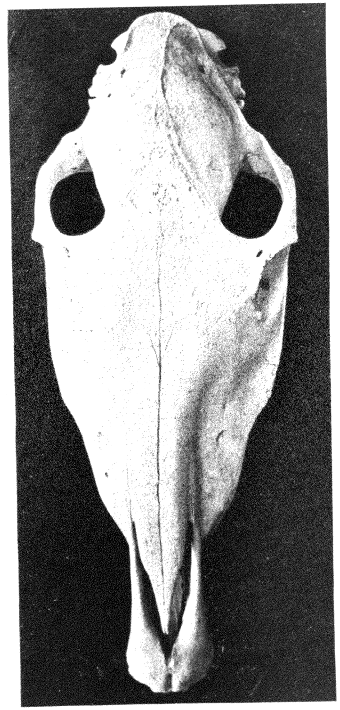
The skull of horse AH8 showing the enlarged alveolar cavities and partly destroyed interalveolar septa.

### TEXT FIGURES

Fig. 1. Segment of transversely ground section through the middle of shaft of the femur of horse AH8 as seen under Spenser dissecting microscope No. 80. Stained black with silver nitrate solution. *a*, Outer, or periosteal, surface; *b*, inner, or medullary, surface; *c*, bits of bony tissue.

2. Segment of transversely ground section through the middle of the large metacarpal bone of horse AH7, drawn under Reichart microscope with ocular No. 1 (13x) and objective No. 3 (10x). *a*, Outer circumferential, or periosteal, lamellæ; *b*, normal Haversian canal; *c*, enlarged Haversian canals; *d*, concentric lamellæ; *e*, inner circumferential, or endosteal, lamellæ.

1



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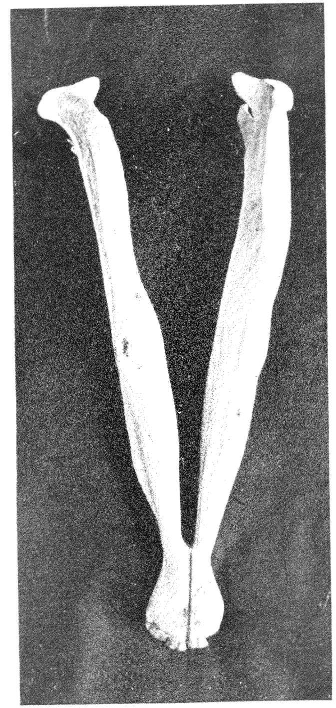

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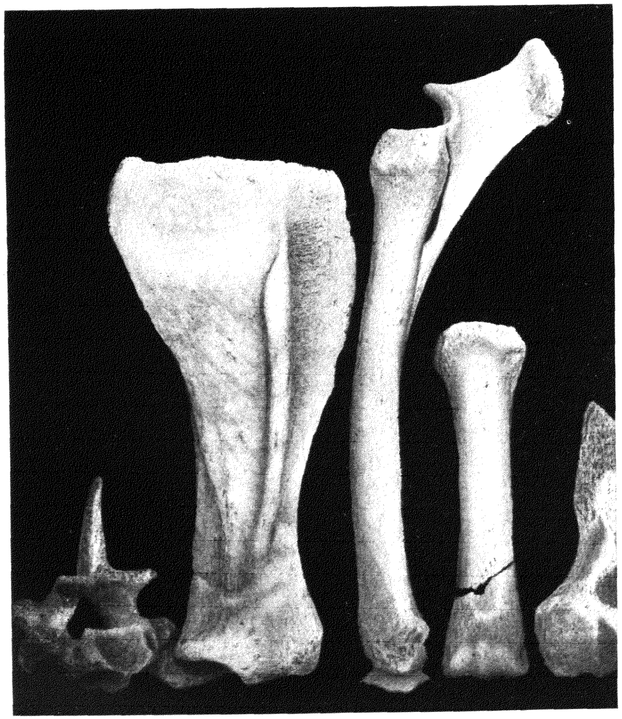
PLATE 1.



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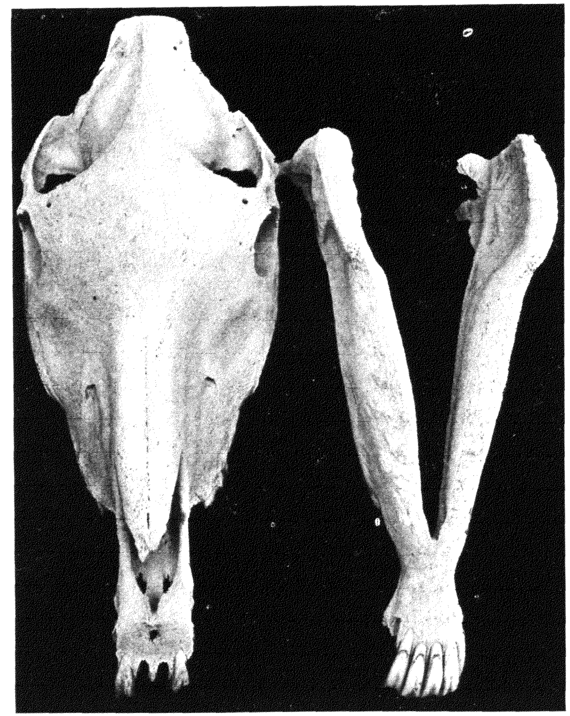

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PLATE 2.

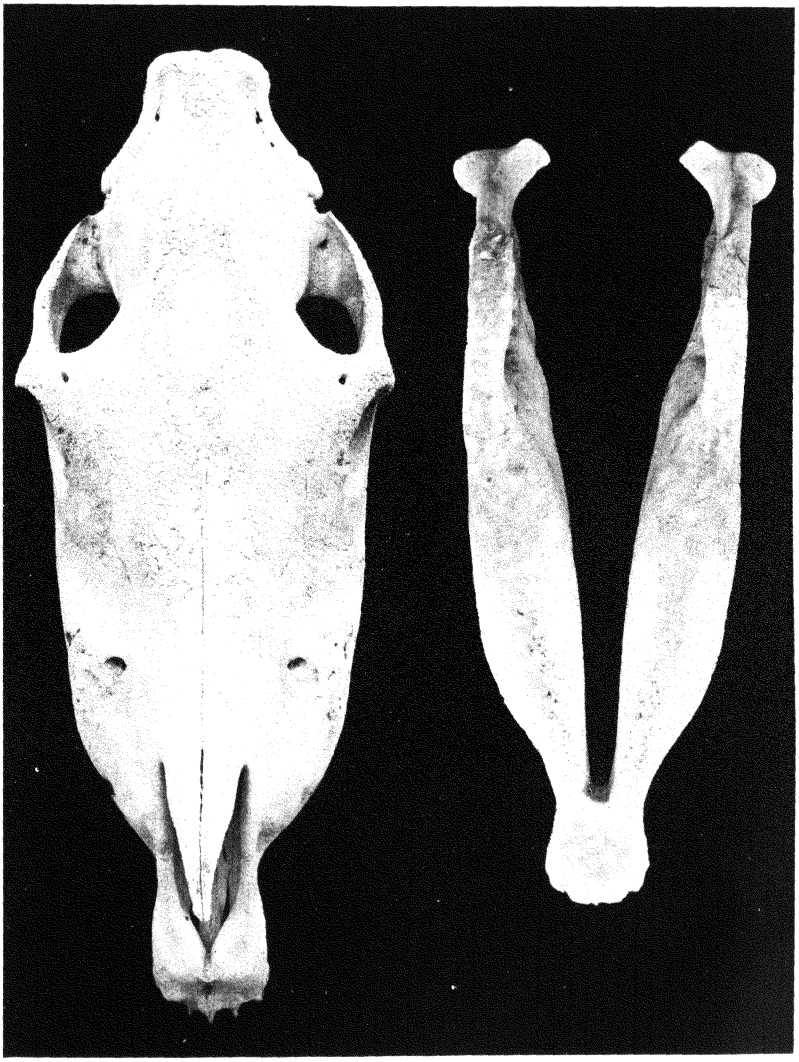

PLATE 3.

PLATE 4.

# A FATAL CASE OF NONDYSENTERIC AMŒBIASIS

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THREE PLATES

## INTRODUCTION

Dysentery has been defined as a symptom-complex consisting of frequent bowel movements, bloody stools, and tenesmus; and ever since Musgrave(6) coined the word "amebiasis," in 1904, a laboratory report of the presence of *Entamœba histolytica* in a stool invariably brings to mind that classical triad of complaints.

However, observations within the last thirty years have brought to light variable types of clinical manifestations other than dysentery when this protozoan parasite gains entrance into the human body. Musgrave,(7) in 1910, described "intestinal amebiasis without diarrhea," and Walker,(10) in 1913, classified carriers in this disease as convalescent and contact carriers. Reed,(8) in 1922, introduced into the nomenclature the term "non-dysenteric amebiasis" to signify conditions in which dysentery does not occur concomitantly with the presence of amœbæ, as in carriers and in the possible but still doubtful amœbiasis of the bones in arthritis deformans, Ely's second great type of arthritis.

The present case is reported for what it may be worth in the study of extra-intestinal infections, it being unquestionably of a nondysenteric type (carrier) but with the sequelæ of abscess formation in the liver, kidney, lungs, and brain.

A detailed résumé of the hospital and autopsy records of the case are herein presented together with the microscopic findings to show its beginning, course, and fatal end.

## CLINICAL RECORD; CASE 61392

*General data.*—R. L., 70-year-old male Filipino, born in Bulacan, residing in Manila, laborer, came to the Philippine General Hospital June 25, 1918, complaining of abdominal pain of three weeks' duration.

*Habits.*—Used to drink wine (ginebra) and tuba; smokes a little.

*Family history.*—Father died of paralysis of half of the body at the age of 70 years. Mother died of a disease unknown to the patient. One sister died of cholera. Has one brother living and well.

*Previous illness.*—Had a fall at the age of 7 years, as a result of which patient was unconscious for two days. At the age of 12, he had another fall which caused dislocation of the right shoulder. At the age of 25, he had "*pasma*," as a result of which the right half of his face became paralyzed.

*Present illness.*—Began three weeks ago with inability of the patient to move his bowels. For this he went to the dispensary of the Philippine General Hospital where he received treatment. He got well apparently after two days, but later he felt pain in the abdomen. For this he was treated by a physician, but there was no relief. So he applied for admission into the hospital.

*Present condition.*—Patient is complaining of severe abdominal pain. Walks with difficulty. Prefers lying in bed.

*Physical examination.*—Patient is a fairly developed and fairly nourished old man, able to sit up and stand but prefers to remain in bed most of the time. Face is asymmetrical. Right half of face unable to contract. Right eye does not close very well. Nose drawn towards the left. Left angle of mouth drawn upward towards the left. Right angle of mouth drawn downward. Teeth are poorly kept. Tongue coated. No palpable masses in the neck, but pulsation is marked on each side. Chest is flat. Supraclavicular fossæ are much depressed. Expansion is very poor.

*Palpation.*—Increase of tactile fremitus over the apices, on the left interscapular area, and just below the inferior angle of left scapula.

*Percussion.*—Dullness over and around the apices, especially over the scapular regions. Dullness over the left axillary region and just below the inferior angle of left scapula.

*Auscultation.*—Respiratory murmur very faint throughout the chest. Respiration bronchial in character, particularly over the apices and the region below the inferior angle of left scapula. Crepitant râles heard over the same region.

*Circulatory system.*—Cardiac area of dullness not enlarged. Apex beat in the fifth interspace along the midclavicular line. Heartbeat normal in rate and rhythm.

*Digestive system.*—Tongue coated; appetite good; bowels constipated.

*Abdominal examination.*—Abdomen bulging on the right side. There is a palpable mass below the right subcostal margin. This mass is firm and connected or continuous with the liver and gives a dull resonance on percussion. The upper border of the liver is at the fifth rib in front; at the sixth interspace in the axillary area, and at the seventh interspace behind along the scapular line.

*Genitourinary system.*—Apparently normal.

*Integumentary system.*—The entire skin is pigmented and of an ashy color giving the appearance of bronze.

*Muscular system.*—Musculature rather thin and emaciated.

*Clinical diagnosis.*—Facial paralysis, right side. Abscess of the liver. Pulmonary tuberculosis.

## OBSERVATIONS AND TREATMENT

Fæces examination was requested once and was negative. Blood examination showed a leucocyte count of 10,000 with a differential of 78 per cent polymorphonuclear neutophiles and 22 per cent of lymphocytes. X-ray showed a general enlargement of the liver and spondylitis deformans of the last dorsal and lumbar vertebræ. July 1, six days after admission, an exploratory puncture was made into the liver. Incision and drainage of the liver abscess were performed July 2. During the twenty-eight days after the operation, the wound was dressed daily and irrigation of the abscess with a solution of quinine bisulphate was made daily. Pain around the operated part was the constant complaint. Cough was persistent so that the giving of bromoform mixture and cresote inhalation were part of the treatment. One cubic centimeter of sodium cacodylate (10 per cent solution) was administered hypodermically once a day to strengthen the patient. Constipation, which was the principal complaint on admission, persisted as a troublesome feature of his illness and the physician in charge ordered cathartic enemata of saturated solution of magnesium sulphate on July 8, 10, and 21.

The patient died July 31, 1918, after thirty-six days in the hospital, with a temperature of 37° C. Fever was of the irregular type. The patient entered the hospital with a subnormal temperature, 36° C. After five days of apyrexia, the temperature rose to 38° C.; it fell to normal and subnormal on several occasions and rose to 38° C. at various times.

## AUTOPSY RECORD; NECROPSY 6276

By Dr. C. MANALANG

Body is that of a well-developed and rather poorly nourished male adult Filipino, 70 years old, 32.50 kilograms in weight and 153 centimeters in length. Post-mortem rigidity slight; lividity slightly present on dependent portions. On the right upper quadrant of the abdomen is a vertical incision scar 10 centimeters in length with its upper extremity at the costal margin. A small strip of gauze is inserted through an opening 1 centimeter in diameter located at the seventh right interspace, 3 centimeters anterior of the right midaxillary line. There are no skin lesions.

On section in the subcutaneous tissue below the previously described scar are sutures. The anterior abdominal wall is adherent to the surface of the left lobe of the liver by means of firm, fibrous bands. The border of the liver extends 5 centimeters below the costal margin. Appendix is normal. The mesenteric glands are not enlarged. The convex surface of the right

lobe of the liver is completely obliterated by adhesions. The lateral surface of the left lung is free, and the right is adherent. The base of each lung is firmly adherent to the diaphragm. The thymus is replaced by fatty tissue. The pericardium contains normal fluid. A strong band of adhesion binds the posterior surface of the left ventricle to the pericardium.

The heart weighs 232 grams. The epicardium is thickened around the adhesion. The right ventricle contains a small amount of clot. Valves normal. The musculature is dark brown, firm, and normal in thickness. The base of the aorta is quite smooth.

The left lung is voluminous and crepitant except a slight partial consolidation of the posterior portion. Cut surface is dark gray, spongy, and very moist with frothy fluid. The consolidated area shows small portions which apparently contain air. The right lung is not removed as a whole, the inferior lobe being left and removed subsequently with the liver. Section of the right lung did not show any gross lesions in the nature of tubercles or caseation.

The spleen weights 77 grams, normal.

The left adrenal weighs 55 grams, normal.

The left kidney weighs 127 grams, cut surface is pale and swollen, the cortex thick. The capsule strips with resistance. The right adrenal and kidney which is smaller than the left are removed with the liver.

The stomach contains a small amount of thick yellowish material. The mucosa is intact.

The small intestine contains a dozen large ascarids. The mucosa is intact. The Peyer's patches in the lower ileum are pigmented but not enlarged. The large intestine contains formed, dark fæces. The mucosa is smooth and pale. No scars or ulcers are visible. Only minute pin-head erosions are visible in the cæcum.

The pancreas weighs 71 grams, normal.

The liver is about normal in size, and the previously described opening on the right side communicates with a cavity in the right lobe. This cavity is located on the posterior and superior portion of the lobe. It extends below the diaphragm, behind the liver, and involves the upper pole of the right kidney. It holds about 300 cubic centimeters of thick, ropy, creamy, and odorless material. Through the diaphragm it communicates with a similar cavity in the lung about 10 centimeters in diameter. The liver tissue surrounding the cavity is firm and infiltrated with white fibrous tissue. The cavity in the lung is surrounded by a firm, white wall, 5 centimeters in thickness. The inner surface of the cavity is lined by a white, soft, granular substance. The diaphragm is thick.

The bile ducts and gall bladder are normal.

The genitalia are normal.

The aorta shows irregular, hard, yellowish plaques.

The head. On removal of the skull, scalp, and dura matter, the anterior portion of the right frontal lobe of the brain is adherent to the dura matter and on removal a cavity the size of a hen's egg is exposed. This cavity is filled with ropy, thick, creamy, blood-streaked material. The surrounding brain is soft and blood tinged. Similar material infiltrates the subarachnoid space covering the inferior surface of the cerebellum. All the basal blood vessels show marked calcification of their walls.

Anatomic diagnosis: Amœbic abscess of the liver, lung, kidney, and brain; generalized arteriosclerosis; bronchopneumonia patch in the left lung; ascariasis.

## GENERAL DISCUSSION

A study of the material on hand reveals the presence of abscesses in the liver, lungs, kidney, and brain, respectively. In all of these lesions, the trophozoites of *Entamœba histolytica* have been found. It is unfortunate that the part of the intestine which grossly showed minute superficial ulcerations is not available. Luckily, smears made during the autopsy from around the ulcers are available and are positive for both the trophozoites and cysts of the parasite. Without a doubt the course of infection could be traced from the intestinal lesions, through the portal circulation into the liver, forming an abscess therein. By contiguity the infection extended to the kidney. The lung abscess might have been produced either by contiguity from that of the liver or through the circulation. The brain abscess is probably metastatic from the liver.

### ABSCESS OF THE BRAIN

The abscess of the brain is single and is located in the anterior portion of the right frontal lobe (Plate 1). It measures 9 centimeters in diameter. The wall of the abscess after the removal of the liquid contents shows a rough, finely nodular surface. Microscopically the amœbæ have been found to be numerous along the walls of the abscess. There is a distinct fibrous lining separating the healthy brain tissue from the necrosed substance of the wall of the cavity, beyond which no amœbæ were detected.

The formation of an amœbic abscess in the brain is extremely rare. In fact, Armitage,(1) who collected all the cases in the literature up to 1919, including his case, gives a total of 49. Armitage gives the geographic distribution of the forty-eight cases as follows: Madagascar, 1; Gulf of Mexico, 1; British India, 5; Indo-China, 7; Egypt, 24; Dutch Indies, 1; Tropical districts not precisely indicated, 2; France, 2; Germany, 1; England, 3.

To this list the present case is added. Armitage says:

> The statistics of the American commission to the Philippines did not record a single case in over 3,000 cases of liver abscess, and it is astonishing that in the rich Anglo-Indian and Franco-Algerian literature of the first half of the 19th Century only rare cases are found.

While I am certain that there has not been reported a case of amœbic brain abscess in the Philippine Islands, I am unable to verify the 3,000 liver abscess mentioned by Armitage. A minute search of the reports of the two American commissions, namely, that of the American Board for the study of Tropical Diseases headed by R. P. Strong, and that of the Johns Hopkins University Medical Commission to the Philippines, headed by L. B. Barker and S. Flexner, failed to confirm his statement. Dobell(4) writing on this point says:

> A good instance of confusion which is met with in the records of amœbiasis may be found in the published figures for the Philippines. We have numerous accounts of the prevalence of E. histolytica infections in the resident population, ranging from 0 to 70 per cent; and whilst the earlier records showed that amœbic dysentery and amœbiasis were responsible for a great part of the sickness and mortality in these islands, more modern and accurate investigation have shown that, although E. histolytica infections are very common, most of the dysentery is really bacillary.

ABSCESS OF THE LIVER, LUNG, AND KIDNEY

From the autopsy protocol it could be safely inferred that the abscess primarily developed in the liver. This has grown in size and by contiguity extended through the diaphragm, forming an abscess in the lower portion of the right lung and downwards to involve the upper pole of the right kidney. The liver, diaphragm, and surface of the right lobe of the lung are well adherent (Plates 2 and 3). The kidney with the abscess occurring superficially was subsequently separated from the adhesions to the liver. The walls of the abscess in the lung, liver, and kidney have practically the same gross appearance; that of the kidney (Plate 3), however, is somewhat nodular, while those of the lung and liver have a shaggy look. In all of these, microscopic examination shows a uniform tendency towards a walling off of the invading organism. There is formation of a more or less definite barrier of connective tissue with coincident inflammatory reaction products around the involved areas.

Rupture into the lung of an amœbic abscess of the liver has been mentioned by Strong(9) and Gilman(5) in their experience in the Philippines, but they have never encountered any kidney involvement.

Regarding liver abscesses occurring singly, Abriol(2) records among Filipinos 83 cases of amœbic colitis complicated by liver abscesses among 3,630 necropsies (1910–1917). Crowell(3) encountered 9 among 31 cases of amœbic colitis. Gilman(5) found 1 among 32 cases. Pains were taken to hunt for cysts of

amœbæ in all the abscesses encountered in the present case, but none was found. Exception, therefore, has to be taken to Abriol's statement that "Occasionally we may find lumps of translucent mucoid yellowish material which as a rule harbors encysted amœbæ."

### THE CARRIER STATE

The evidence shows that this patient belongs to the group of "non-dysenteric amœbiasis" cases more commonly known as carriers. Smears from the intestinal contents showed abundant tetra-nucleated encysted forms of *Entamœba histolytica.* A feature that should be borne in mind in the present case is the symptom of obstinate constipation. Attention is also called to the fact that this occurred in spite of the existence of several minute superficial erosions of the intestinal mucosa as reported at autopsy. Therefore, the criterion, according to the classical definition that "a carrier is one who is clinically normal except that he harbors resistant forms of organisms that may infect other persons," needs revision in the sense that he is not totally devoid of danger to himself.

### SUMMARY

1. The case is reported of amœbic abscesses occurring in the brain, lungs, liver, and kidney without concomitant dysentery.
2. The first case of amœbic abscesses of the brain in a Filipino is recorded.
3. A carrier is a source of danger not only to other persons but also to himself.
4. Thorough and repeated fæcal examinations for amœbic cysts should be made in order to discover carriers not only in diarrhœics but also in constipated individuals with complaints of vague pains in the abdomen. Early detection of cases, and intensive treatment with emetine or other amœbicidal substances may save many a patient from a fatal end. Study of the returns of enemata is indicated in a case like this one in which the patient was constipated to a marked degree.

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## ILLUSTRATIONS

PLATE 1

Amœbic abscess of the brain. Note the shaggy appearance of the right frontal lobe. A portion of the brain tissue is cut for microscopic study.

PLATE 2

Amœbic abscesses of the liver and lung. The abscess is opened to show the characteristic wall of the abscess. A portion of the lung containing the abscess is seen adherent to the diaphragm.

PLATE 3

Amœbic abscess of the kidney. The abscess is confined to the cortical surface of the kidney.

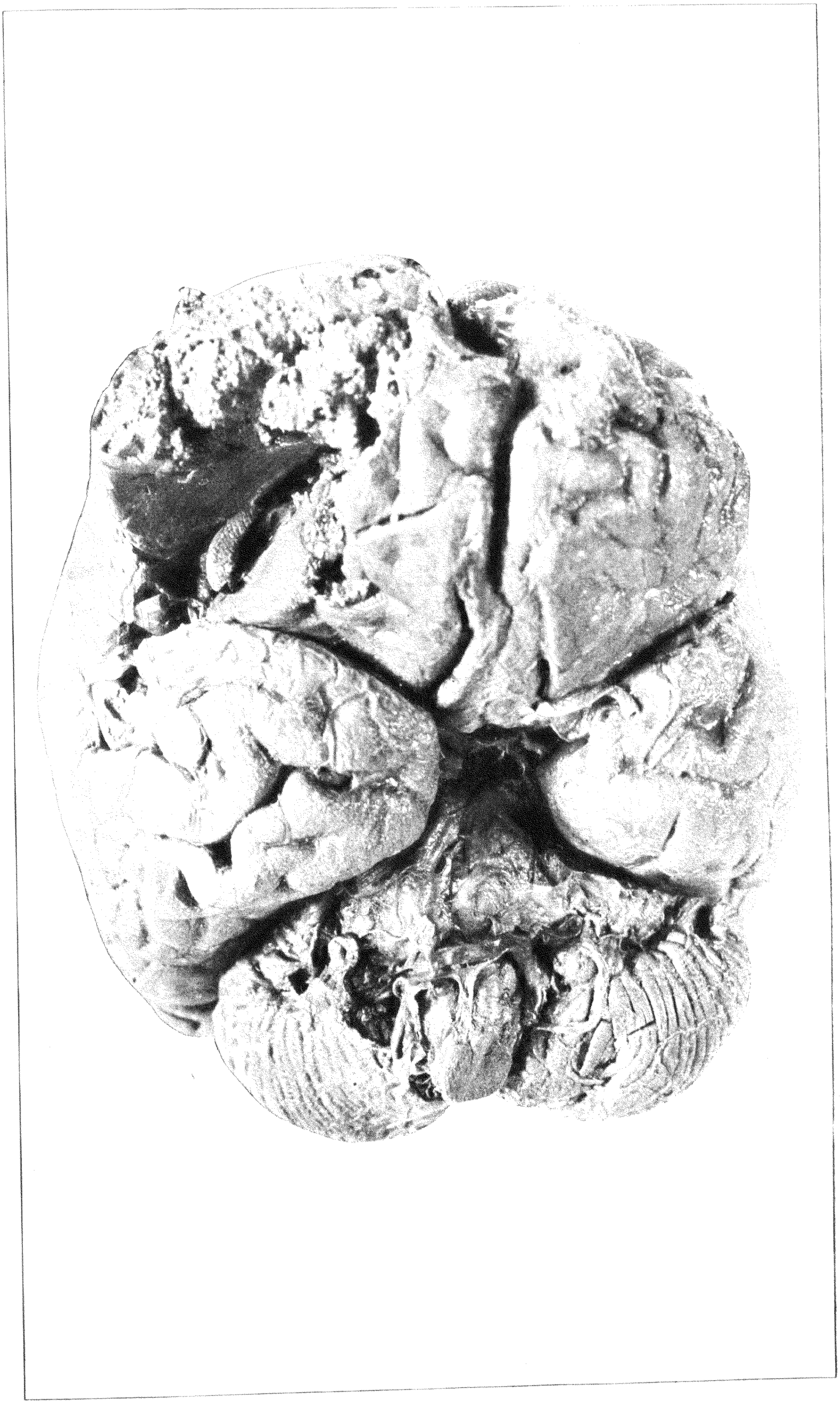

PLATE 1.

PLATE 2.

PLATE 3.

# THREE CASES OF POISONOUS INSECT BITE INVOLVING TRIATOMA RUBROFASCIATA

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ONE PLATE

Cases of poisonous bite by insects, centipedes, spiders, and other venomous arthropods are of frequent occurrence in this country. While in many cases the symptoms presented are of such trivial nature that practically no attention is paid to them, in certain instances severe local and constitutional symptoms, more or less alarming or dramatic in nature, are observed. It is only on occasions like these when the interest of the patient or of the family is aroused, that a physician is summoned. When an inquiry is made concerning the offending bug, more often than not the "corpus delecti" cannot be produced, or at most the patient or his family can give only an unsatisfactory description of the animal that inflicted the bite. Consequently the offense is in most cases attributed to almost any kind of bug except the actual offender. It is seldom that the actual offender is caught red-handed.

Recently three cases of severe insect bite with symptoms of actual poisoning were brought to the attention of the writer. In each case the offending bug was captured under circumstances that would permit no doubt as to its culpability. The symptoms observed in the three cases were almost identical, and the captured insects all answer closely the description of *Triatoma rubrofasciata* de Geer, 1773. These three cases are the first of their kind ever recorded in the Philippine Islands, although in many other places this insect has been known to inflict severe bites with marked local and constitutional symptoms. For the interest of Philippine practitioners, case reports and a short description of the insect are given here.

CASE I[1]

I. S. H., male Chinese, 23 years old, single, merchant by occupation, residing in Binondo, Manila, when seen by Dr. Wee was complaining of swollen lips, numbness of the extremities, subcutaneous swellings in different parts of his body, general weakness and pain over the right scapular region which he alleged, was bitten by a bug which he had caught and given to the doctor. According to the patient, he was suddenly awakened by a painful prick over the right scapular region the previous night. Soon after, he felt intense itching at the site of the bite. However, he was able to resume his sleep after some time, but about three hours later he awoke to find himself in severe rigor which lasted for an hour. After the chill he experienced numbness all over his body, which lasted till the next day. Simultaneously his lips became enormously swollen and an enormous wheal appeared on the site of the bite and other parts of the body such as the region around the eyes, nose, and extremities. The doctor was summoned about six hours after the alleged bite. He found the patient lying in bed, apparently weak, with a temperature of 98.2° F., pulse 86, respiration 28, and blood pressure, 120–70. The patient talked with effort due apparently to the swollen lips. The right scapular region was still swollen and inflamed; other similar swellings were found over the eyes, nose, and extremities. No definite mark of the prick could be detected at the alleged site of the bite which was still swollen and œdematous. Pilocarpine was given hypodermically to induce diaphoresis, aspirin to control pain, and strong ammonia water locally to relieve itching. The patient made rapid recovery and in two days all the symptoms disappeared except for the patches of desquamation which marked the site of the swellings.

CASE II

P. P. B., a male Filipino, student, 23 years old, single, residing in Ermita, Manila, came to the University of the Philippines Infirmary complaining of slight headache and reddish swelling of the left upper extremity with hot sensation over the same. He claimed to have been bitten by a bug, which he was able to capture at about 3.30 a. m. of the same day. The site of the prick was at the inferior portion of the left scapular region.

[1] Cases I and II were furnished through the courtesy of Drs. Wee and J. Perez, of Manila, respectively.

The patient felt an itchy sensation all over the left upper and lower extremities just a few minutes after the prick necessitating scratching of the parts. He applied "Katialis" and Sloan's liniment over the itchy portions. He did not notice any wheal formation or swelling of the parts until the time he woke up the following morning, when he found erythematous patches over the left scapular region and diffuse swellings of the left upper extremity. The swellings were very much reddened. He further felt hot sensations over the face, which was also reddened, and over the left lower extremity.

On examination finger scratches were found on the left scapular region. There was noted a solitary erythematous patch about the size of a ten-centavo piece. As in the preceding case, no definite mark of the prick could be seen. The left upper extremity was diffusedly swollen and reddened. The skin over the same was hot. The face and left lower extremity, which he alleged were affected soon after the bite, were found normal. The temperature was 37.5° C.

Complete recovery followed soon after treatment with ammonia water and hot alum acetate compress locally and aspirin and sodium bicarbonate per os.

CASE III

M. S., female Filipino, married, 30 years old, housewife, residing at 193 Fabia, Tondo, Manila, was seen by the writer on the morning of August 20, 1933, complaining of malaise, slight headache, giddiness, tingling sensation in the ears and swelling of the whole right hand and parts of the forearm, which she described as hot, numb, and intensely itchy. She claimed to have been bitten in her sleep on the back of her hand the previous afternoon by a bug which she presented to the writer. The site of the prick was so itchy that she had to scratch it furiously. Soon after the back of her hand became numb and began to swell, the swelling rapidly extending to contiguous parts, so much so that by nightfall of the same day all her fingers and wrist were involved. That night she was not able to sleep well on account of the intense itching of the affected parts. On examination about twenty hours after the bite, the patient was found feverish with slightly accelerated pulse. The whole right hand, including the lower half of the forearm, was diffusedly swollen, hot, and reddened. The fingers of the affected hand were blotched and flexion was difficult (Plate 1, fig. 1). At the base of the middle finger, on the back of the

hand, could be detected a small weeping puncture about half a millimeter in diameter, presumably the site of the prick. No other swelling was found in other parts of the body. Pyramidon internally and strong ammonia water locally were given and the patient was allowed to go home. When the patient returned two days after, no trace of the swelling could be found except a patch of desquamation at the site of the prick.

*Triatoma rubrofasciata* is a blood-sucking reduviid which is known, wherever it is found, to attack man and other vertebrates inflicting on its victim a severe bite, which is at times followed by severe general symptoms, such as swelling in different parts of the body, nausea, etc., as well as much local pain and irritation.

The character of the symptoms observed in cases of *Triatoma* bites suggests both inflammatory and neurotoxic poisons. The nature of the venom is still unknown but probably it is a mixture of highly complex proteids similar to the venom of bees and wasps. Cornwall and Patton (4) found in it a highly developed anticoagulin. The severity of either local or general symptoms would depend on whether the poison is injected subcutaneously or into a vein. If the poison is introduced subcutaneously, the general symptoms are much less pronounced than the local manifestations as it would take longer for the venom to be absorbed by the blood and distributed to the different parts of the body. On the other hand, the effect of entry into a blood vessel is to produce immediately constitutional symptoms, which are as a rule more alarming than the local ones. The degree of poisoning would also depend to a large extent on whether or not the insect has recently spent its stored venom on other victims. These different factors tend to explain the varying severity of bites alleged to be inflicted by this insect. Thus Patton (1913), who has fed a large number of adults and nymphs of this insect on himself and has recorded the effects of their bites, failed to mention any constitutional symptoms. Among other things he mentioned that twelve hours after the bite a large erythematous patch about the size of a shilling appeared at the site of the puncture; it remained in an inflamed and extremely irritable condition for about a fortnight and then faded away; a small nodule about the size of a No. 6 shot persisted for about a month.

The appearance of local œdematous swellings in the different parts of the body of the victim suggests a kind of toxin that

upsets the vasomotor mechanism in certain susceptible areas of the body. The importance of this phenomenon may readily be appreciated by bearing in mind the possibility of the glottis becoming the site of such vasomotor disturbances and consequent œdema.

It is interesting to note that in two of the foregoing case reports, the site of the bite was in the scapular region, and that the prick in both cases occurred while the patient was presumably in the recumbent position. This seems to support the contention of Patton and Cragg (1913) that this insect attacks man only under exceptional circumstances, as when it is carelessly handled. The senior author was able to feed as mentioned above, a large number of adults and nymphs of this insect on himself. The authors did not, however, mention whether or not these adults and nymphs were carelessly handled.

The insect is large, measuring from 19 to 24 millimeters in length, and is easily recognizable. In general appearance it resembles the common garden bug, or "vaca-vacahan," but it is much larger and differently colored. The eyes are very prominent and form two lateral rounded swellings at the sides of a long roughly rectangular head; the ocelli, which are behind and above the eyes, are well developed, and often appear as clear spots. The proboscis is short and stout and is held in a looped manner under the head (Plate 1, fig. 2). The following is the description of this insect by Patton and Cragg (1913).

### *Generic Diagnosis*

### GENUS TRIATOMA WOLF, 1802

*Reduviidæ.* Head long, porrect, more or less distinctly impressed behind the eyes; rostrum with the first joint very much shorter than the second; antennæ inserted on the sides of the head about midway between eyes and apex; ocelli placed very far apart; prosternum broadly sulcated; abdomen strongly ampliated, not centrally carinate, frequently with the disk prominently flattened; posterior tibiæ longer than the femora. (Distant.)

### *Specific Diagnosis*

### TRIATOMA RUBRUFASCIATA DE GEER, 1773

Pisceous brown. Head dark brown to black with the basal margin reddish. Antennæ with first joint not quite reaching apex of the head; second joint three times the length of the first; basal joints dark, apical joints light. Pronotum dark brown to black; anterior angles produced into two short spines of a reddish yellow color. Two blunt prominences ending in diverging ridges on anterior portion of dorsal surface of pronotum; lateral margin of pronotum to posterior angles with a reddish yellow linear

streak; scutellum dark, apex occasionally reddish; corium with a basal oblique linear streak and a somewhat diffuse subapical reddish yellow spot; wing membranes fuscous. Connexivum with reddish yellow lateral spots on dorsal surface, which as a rule extend to the margin and form a continuous reddish yellow edging to the abdomen. Length 19 to 23 mm. (Patton and Cragg.)

*Triatoma rubrofasciata* has a very wide geographical distribution, although it is believed to be a true Oriental species which has spread to other areas. It has been reported in Brazil, Haiti, Argentina, China, Madagascar, Sierra Leone, Mauritius, Zanzibar, Tanga, Sumatra, New Guinea, Indo-China, Borneo, Java, Ceylon, Singapore, Formosa, Japan, and the Philippines. In the entomological collection of the Department of Parasitology, School of Hygiene and Public Health, University of the Philippines, the author found four specimens labeled *Megistus rubrofasciatus* de Geer (= *Triatoma rubrofasciatus*) by Banks in 1915. They were collected in Manila and vicinity. Specimens of this species were also collected by the author in the same localities. The adult seems to frequent vines like squash, "opo," "patola," and the like. Patton and Cragg (1913) were not able to encounter the early stages of this insect in holes in the ground or about roots of trees after intensive search in localities where adults are common, indicating that this insect is arboreal in habit. According to Comstock (1910) nearly all reduviids live upon trees and other plants and prey upon other insects. This insect frequently enters houses at night, and if the alimentary tract of the insect is dissected out, it will be found to contain mammalian blood. Whether or not it feeds regularly on human blood is not known. If it does, it is worth bearing in mind that *Triatoma megista*, a closely allied species, is the confirmed invertebrate vector of Chagas fever, a fatal form of human trypanosomiasis in many parts of Brazil. Pathogenic trypanosomes, as shown by the behavior of the causative organisms of sleeping sickness, seem to show a tendency to use more than one invertebrate intermediary host. For this reason, *T. rubrofasciata* as a potential vector of Chagas fever, should be considered. The possibility of introducing this dangerous disease to new areas does not seem improbable, especially if we consider the fact that it runs a chronic course and does not prevent its victim from making long trips to other places or from settling in new areas. Because of modern facilities of transportation, the world's population is becoming more and more mobile, and diseases which were formerly more or less

confined within limited areas have been found to have crossed mountain and ocean barriers with the stream of human migration. Thus we see that *Diphyllobothrium latum* infestation has gained a permanent foothold in the region around the Great Lakes of America while *Schistosoma mansoni* infection has become endemic in the West Indies and parts of South America. The former was introduced into the new endemic area presumably by the Fins and Scandinavians who migrated from the region around the Baltic Sea where this tapeworm is a common infection, and the latter by the Negro slaves who were brought to the New World from Africa in the early part of the seventeenth century. Since these two worms cannot establish themselves in areas where their respective intermediary hosts are absent, it is evident that their vectors or at least species closely allied to them, are present in the regions where they have been recently introduced and remained endemic. As a large number of Japanese are now populating different parts of Brazil, it does not seem far fetched to conceive of a similar situation arising in the future whereby Japanese immigrants visiting their home country and other areas in the Far East, may introduce Chagas fever into these virgin areas by virtue of the presence of *Triatoma rubrofasciata*, a cogeneric species of the confirmed vector of this disease in Brazil. Recently Kofoid and Donat (1932) succeeded in transferring experimentally a trypanosome which they believed (as a result of a long and painstaking investigation) to be identical with *Trypanosoma cruzi*, from experimentally infected *Triatoma protracta* to mammals in California.

It might be mentioned also that *Triatoma rubrofasciata* is commonly infected with a flagellate, *Crithidia conorhini* Donovan, in Madras where it has been suspected, though on slender evidence, as a transmitter of kala azar. In Mauritius Lafont has found 80 per cent of this insect infected with a similar flagellate with which he was reported to have succeeded in infecting rats and mice with a trypanosome by inoculating it intraperitoneally. As most of his animals died apparently on account of the infection, he draws attention to the possible rôle this flagellate may play in the case of man. Another line of investigation, suggested by the presence of this insect in this country, is the possible rôle it may play in the transmission of surra, another trypanosome disease which causes a large number of deaths among horses every year. The fact that this insect seems to be arboreal in habit, living as it does among domestic

vines and other plants and in close proximity to the common haunts of our domestic animals, and the further fact that it has been found to feed avidly on mammalian blood in nature and in captivity, would strengthen suspicion in this direction.

## SUMMARY

Three authentic cases of *Triatoma* poisoning, believed to be the first recorded in the Philippine Islands, with local and constitutional manifestations usually observed in bites by this insect as reported in other countries, are discussed in this paper. The possible rôle of *Triatoma rubrofasciata* in the transmission of important blood-flagellate infection is discussed.

## ACKNOWLEDGMENT

The writer is gratefully indebted to Dr. Jose Perez and Dr. Wee, of Manila, for their courtesy in placing their clinical data at his disposal.

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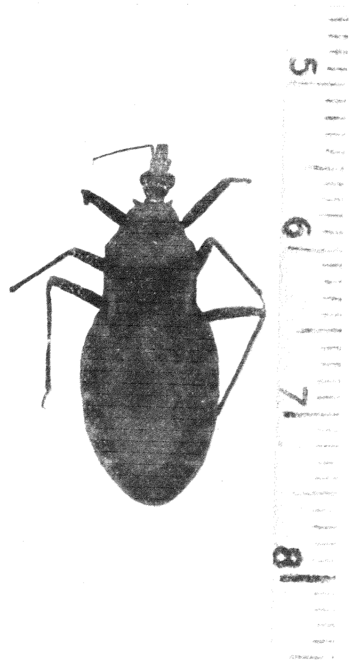
# ILLUSTRATION

PLATE 1

FIG. 1. Case 3, right forearm and hand, showing the swelling caused by *Triatoma* bite.

2. *Triatoma rubrofasciata* de Geer; female.

1




2

PLATE 1.

# EXPERIMENTAL INQUIRY INTO THE TRANSMISSION OF RAT-BITE FEVER AMONG RATS, PART II

## SUCCESSFUL TRANSMISSION OF RAT-BITE FEVER BY FEEDING INFECTED ORGANS TO WHITE RATS

By SHIZUKA ARIMA[1]

*Of the Division of Biological Products, Bureau of Science, Manila*

In part I[2] of this investigation I summarized the results of my experiments concerning this subject. Attempts to transmit rat-bite fever to white mice by offering them guinea pig's organs containing *Spirochæta morsus muris* as food, failed to convey the infection to these experimental animals. It was observed, however, that white mice do not take raw meat and organs readily as food and for this reason further experiments were arranged in which laboratory white rats were used instead of white mice. Under such an arrangement the experiments were successful, for white rats, like their wild gray cousins, devour raw organs readily. Furthermore, the fact that white rats are more closely related to wild rats than are white mice, gives added weight to the present experiments.

### METHODS

The methods of feeding infected material to the experimental rats were as follows:

1. Organs and tissues, such as blood, liver, spleen, kidneys, and suprarenals, of guinea pigs infected with Manila strains of *Spirochæta morsus muris* were given to white rats to eat.

2. Blood withdrawn from infected guinea pigs by heart puncture was mixed immediately with cow's milk and given to the rats as food.

In the first instance the infected donor, as can be surmised, had been sacrificed and in the second method the blood was withdrawn from a living infected guinea pig. In either case the presence of spirochætes in the material offered as pabulum

[1] Surgeon Lieutenant Commander, Imperial Japanese Navy.

[2] Philip. Journ. Sci. 52 (1933) 89–95.

was ascertained by dark-field microscopic examination immediately before feeding. The pabulum prepared in one way or the other was readily taken by the white rats.

In judging the results of the experiments, we have not satisfied ourselves by merely noting the symptoms of the infection, but considered a transmission experiment as successful only when spirochætes were demonstrated by microscopic examination either directly in the blood of infected rats or in that of guinea pigs to which blood or the organs of rats experimented on have been transferred by inoculation.

## EXPERIMENTS

Three normal, laboratory-bred white rats (R–1, R–2, and R–3) were used in one set of experiments. To facilitate infection I have artificially scarified the gums of one of the three animals (R–1). The other two were left without interference.

To these three animals infected guinea pig's organs were fed December 20, 1932, and January 10, 1933. They ingested infected blood January 4, 5, 17, and 20, 1933. During these dates they were also fed freely on milk mixed with blood containing spirochætes.

The blood of the white rats was examined daily beginning December 20, 1932, either fresh under the dark-field microscope or in the form of stained blood smears, but spirochætes were not found. It appeared, therefore, that the results of this experiment, like those on white mice, would be negative. The possibility, however, occurred to us that the rats may be relatively immune and, consequently the spirochætes invade the blood stream, if at all, in such small numbers that even careful and repeated examinations fail to reveal them. In order to decide this point I infected one of the rats (R–2) with material rich in spirochætes by subcutaneous injection and examined the rat's blood at frequent intervals of time. As I suspected that the spirochætes, if found at all, would be very few and hard to find, I began to take the blood with distilled water in order to eliminate the interference of red blood cells in the search for spirochætes. On the forty-second day after infection one typical spirochæte was found by dark-field illumination, but the search in stained smears was fruitless. In order to confirm this finding I withdrew blood from the same rat and injected it into a guinea pig, which in due time developed the disease with positive finding of spirochætes. Thus it was learned that under the most

favorable conditions *Spirochæta morsus muris* rarely invades the blood stream of white rats and in small numbers at that.

A similar procedure, however, performed on rat R-1 January 11, 1933, failed to produce the disease in a guinea pig inoculated with the rat's blood. This rat, it will be noted, ingested repeatedly infected organs, blood, and milk, but has never been injected with spirochætes.

In view of these difficulties, I sacrificed the two remaining rats that had been fed repeatedly on material rich in *Spirochæta morsus muris* and separately inoculated normal guinea pigs with the organs of these rats. The guinea pigs promptly developed rat-bite fever with positive findings of the specific parasites. To check the results two other white rats (R–4 and R–5) were fed with the organs of these animals February 27, March 30, and April 3, 1933. These rats were killed April 14, 1933, and their organs were inoculated separately to two clean guinea pigs. One of these guinea pigs developed rat-bite fever, while the other failed to show any signs of the infection during a period of observation that lasted forty-six days.

From the results of the above experiments, we believe the following conclusions are justified:

## CONCLUSIONS

1. White rats, more than white mice, are partially resistant to Manila strains of *Spirochæta morsus muris* that have been proven to be very virulent for guinea pigs, rabbits, and Philippine monkeys.
2. Experimental evidence presented in this communication points to the possibility of transmission of rat-bite fever among rats by the ingestion of recently dead infected rats.

## ACKNOWLEDGMENT

I wish to thank Dr. Otto Schöbl, formerly of the Bureau of Science, for his suggestions during the progress of the work and for reading the manuscript, and Dr. William H. Brown, director of the Bureau of Science, for permission to do investigation work in the biological laboratory of the bureau.

# THE PHYSIOLOGY OF REPRODUCTION IN SWINE, I [1]

## THE SEMEN OF BOARS UNDER DIFFERENT INTENSIVENESSES OF MATING

By AGUSTIN RODOLFO

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ONE TEXT FIGURE

The study of the physiology of reproduction in swine is of great theoretical and practical interest; and the Soviets, under whom these studies were begun, admit that the importance of the theoretical aspect of the work is enhanced by the fact that it sheds light upon the practical or utilitarian aspects. It is hoped that ultimately such studies may lead to a better theoretic understanding of the reproductive processes, and as a result bring about the possibility of devising more rational breeding practices. These studies, however, hardly scratch the surface, and the writer cannot attempt any more than to point to some of the more salient biological problems involved.

## EXPERIMENTAL WORK

*Object of the experiment.*—This experiment was planned primarily to determine the quantity of sperm that is ejected by a boar under different intensivenesses of mating. First, under a light mating schedule, the volume of the semen and the density and the total number of spermatozoa in the whole ejection were determined, and after that the effect upon these quantities of different intensivenesses of mating. In the course of the experiment, we noted the mating behavior of the boar, the activity of the spermatozoa in the semen from the first mating of the boar, and also certain morphological characteristics of the spermatozoa.

[1] The data presented in the first three papers of this series were worked out in the "All-Union Research Institute for Swine Husbandry," Poltava, Ukraine, U. S. S. R., with which the writer was connected as geneticist during the period 1930–1932.

*Material.*—At the beginning of the experiment there were twenty-four Yorkshire boars. These were taken from stock which had been in the Ukraine a number of generations, and were apparently fully acclimated. Two were over 4 years old, one was 3 years old, two were 2 years old, and the rest were 1 year old or less. There were six 8-month-old boars. The two oldest boars were to be used in determining the effect of age, if any, upon the production of sperm, but they would not mate properly.

*Ration.*—The ration of the boars consisted of a grain mixture containing barley, 75 parts; bran, 15 parts; sunflower oil meal, 10 parts. The amount given each animal depended upon his weight, as required by the unit system of feeding. Because of difficulties connected with the general grain shortage in the country, this mixture was somewhat altered temporarily three times during the course of the work. When such an alteration was made, collection of semen was suspended for at least two days thereafter.

A simple mineral mixture consisting of 20 parts common salt ($NaCl$) and 80 parts calcium carbonate ($CaCO_3$) was also given.

The ration was supplemented by greens eaten by the animals in the course of their daily exercise in the grassy yard.

*General care.*—All the boars were housed in the same barn. They were given at least an hour's walk every day. The pens were washed daily, and the animals themselves were washed and scrubbed once a day.

## METHODS

*Method of collecting the semen.*—An old method of collecting the semen of domestic animals consisted in inserting into the vagina a piece of sponge which absorbed the semen, and then withdrawing it to squeeze out its contents. Experience showed that this method cannot be used with the sow. First, because of the narrowness of the vagina of the sow, and, just as important, because of the presence of the sphincter between the vestibule and the vagina, it is impossible to insert a sponge large enough to absorb all the boar's semen. We know now that the boar secretes an average amount of 252.8 cc of semen, a volume that could be absorbed only by a sponge too large to insert into the vagina. Second, the secretion by the boar of the vaginal plug would probably interfere even if we could insert a sponge of adequate size. Third, as a sponge has no selective power of ab-

sorption, it would absorb not only the semen but also any other secretions in the vagina. Fourth, a sponge has to be squeezed, and not all the semen could be squeezed out. A considerable quantity would remain adsorbed by the sponge.

The foregoing considerations show that a mechanical means of collecting the semen is a desideratum, for it would make possible the collection of all the semen ejected in pure condition. McKenzie (1931) first devised a method of mechanically collecting semen from the boar. This method consists in having the penis inserted into a soft rubber tubing which is so manipulated as to impart to the penis a pulsating action. It is doubtful, however, if the full ejection was obtained by the use of this method. A more convenient instrument, the artificial vagina, was later invented in the Laboratory of Artificial Insemination in Moscow, and somewhat improved in the writer's hands (fig. 1).

The artificial vagina is very simple to construct and to prepare for use. The bicycle inner tubing must be put on by folding its ends over the ends of the larger tube, the sides of which are insulated in order that the temperature of the water may be kept fairly constant for the required period of time. That done, warm water (temperature, 40 to 42° C.) is introduced into the cavity between the bicycle inner tubing and the larger tube through the side tube *b*, with the stopcock on the side tube *a* open to allow the air that is displaced by the water to escape. Enough warm water should be put in so that as much of the air as possible is displaced. Then side tube *a* is closed by means of the stopcock. The rubber bulb is attached tightly to the side tube *b*.

The funnel-shaped piece of rubber at the opening of the vagina acts as a guide for the penis to get into the slitlike canal of the artificial vagina. At the opposite end is the glass vessel for collecting the semen. Once the penis gets into the artificial vagina, pulsation is produced by exerting and releasing pressure on the rubber bulb.

The pulsating action is necessary for the completion of the coitus, in the case of animals which take a long time to complete the sexual act, but for those which complete the coitus simultaneously with the insertion of the penis, as in the case of the ram, it is not necessary.

At first the lumen of the artificial vagina was smeared with vaseline the action of which on the spermatozoa had previously been tested. Experience has shown, however, that it is not at

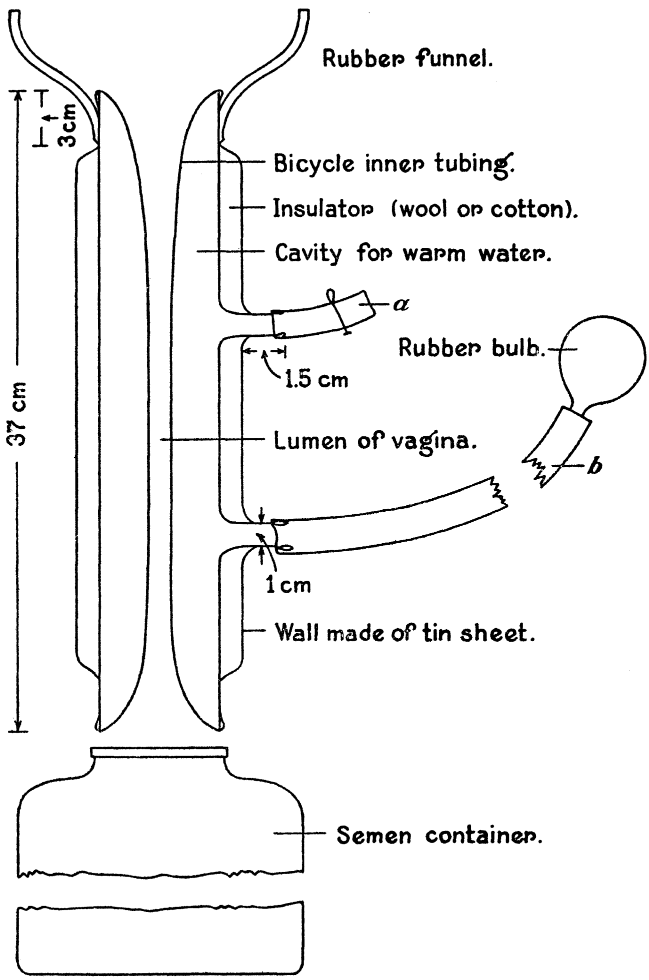


FIG. 1. Longitudinal section of artificial vagina.

all necessary to use vaseline, for when the glans penis meets with the opening of the vagina the first two secretions are squirted, and these secretions are a sufficient lubricant for the penis. There is the advantage also of having no foreign substance incorporated in the semen.

The boar is allowed to mount a sow, and the penis is taken and directed into the artificial vagina, which is held by the other hand. McKenzie noted that the sow does not have to be in heat; she can be tied by the upper jaw to a post, and to prevent her from side-stepping the use of the breeding crate is very convenient. Later, a dummy sow was found to be much more

convenient to use as a decoy, for it does not have to be tied and it does not side-step. Besides, the vagina may be placed as in the natural sow, so that one does not have to bother holding it. The use of the dummy is also practicable for the stallion and the bull. I have seen a wether used instead of a ewe as a decoy.

*The matings.*—A calendar of mating was made out and followed as closely as conditions permitted.

*Measurement of the volume of the semen.*—The volume of the semen is measured by means of an ordinary graduated cylinder. This is accurate within 5 cc. The ease with which foam is formed and the relatively large diameter of the cylinder are the principal sources of error. For a semen sample of 300 cc or more this is a small error; for smaller samples, it is proportionately greater.

*Counting the spermatozoa.*—The number of spermatozoa per cubic millimeter was determined by means of the Thoma-Zeiss blood counter. We took 1:10, 1:20, 1:50, or 1:100 dilutions of the semen, depending upon the density of the spermatozoa. Toisson's fluid was used as diluent. The counting was done as in making the familiar blood counts. At least two counts of each sample were made, and their average was taken as the correct value.

*Records.*—The date of each mating, the volume of the semen, the density of the spermatozoa (that is, the number of spermatozoa per cubic millimeter), and the total number of spermatozoa in the ejection were recorded.

*Preparations.*—At least three slides were prepared from each sample of semen. The fixation was done by heat, followed, after cooling, with immersion in 95 per cent alcohol. The slides were then stepped down through the different grades of alcohol to the aqueous stain. Staining was done with Heidenhain's iron-hæmatoxylin. The hæmatoxylin was ripened by Shortt's method.

## THE SEMEN

*The semen from the first mating of the boar.*—There is a current belief that the spermatozoa in the semen from the boar's first mating in life and from the first mating in a breeding season are dead or in some way nonfunctional. For a few cases this idea apparently holds true. Of the nineteen boars from which we were able to gather semen during the course of the experiment four were 2- to 3-year-old boars, three of which

had already mated before, and one, boar 1883/284, never had mated; the rest were young boars that were being mated for the first time. These, therefore, constituted good material for testing this belief.

Bogdan /61, a 13-month-old boar mating for the first time, mated normally, but during the early part of the experiment gave only nonmotile spermatozoa. His record is given in Table 1.

TABLE 1.—*Semen from boar Bogdan /61.*

| Date of mating. | Volume of semen. | Condition of spermatozoa. |
|---|---|---|
| | *cc.* | |
| May 25 | 175 | Nonmotile. |
| May 29 | 60 | Do. |
| June 2 | 65 | Do. |
| June 7 | 105 | Do. |
| June 13 | 75 | Do. |
| June 15 | 96 | About 1 per cent of the spermatozoa were motile. |
| June 19 | 160 | About 95 per cent of the spermatozoa were motile. |
| July 2 | 127 | Almost all were motile. |
| July 5 | 225 | Do. |

Two other boars gave nonmotile spermatozoa, though their record was far from being as bad as that of boar /61

TABLE 2.—*Semen from boars 2200/91 and 2703/190.*

| Boar No. | Date of mating. | Volume of semen. | Condition of spermatozoa. |
|---|---|---|---|
| | | *cc.* | |
| 2200/91 | June 1 | 510 | Nonmotile. |
| 2200/91 | June 14 | 200 | Do. |
| 2200/91 | June 16 | 315 | About 90 per cent were motile. |
| 2703/190 | June 11 | 35 | Nonmotile. |
| 2703/190 | June 27 | 312 | About 60 per cent were motile. |

Boar 2200/91, a 2-year-old animal, had mated before, while 2703/190, a 12-month-old boar, was mating for the first time.

Since the summer of 1931 we had an opportunity to mate most of the nineteen boars once more after five months of sexual inactivity. Boar /61 was remated December 13, 1931. He gave 215 cc of semen in which 50 per cent of the spermatozoa were nonmotile and agglutinated. January 4, 1932, he gave 350 cc of semen containing spermatozoa that were all nonmotile.

January 7 he gave 309 cc of semen with nonmotile spermatozoa; January 10 he gave 290 cc with almost 100 per cent motile spermatozoa. Boar 2703/190 was remated January 9, 1932. He gave a sample of semen in which the spermatozoa were practically all nonmotile; only about 0.5 per cent were active. From subsequent matings, however, only motile spermatozoa were obtained. Boar 2200/91, on the other hand, gave motile spermatozoa January 10 and on two subsequent matings.

These three cases were interesting because they form exceptions to the rule. The sixteen others gave very lively spermatozoa on the first and subsequent matings. Since the former were given the same care and food, and kept under the same conditions as the sixteen others, the phenomenon of the presence of dead spermatozoa in their semen can hardly be attributed to environmental conditions. For, if these were responsible, the former should have continued to give nonmotile spermatozoa, for one thing, and for another, the other sixteen boars should have produced semen with nonmotile spermatozoa, which they did not. One would explain this condition as a case of the presence of gametic lethal genes were it not for the fact that after a few matings active spermatozoa were again obtained.

The real explanation is probably to be found in some phenomenon or phenomena of a physiological nature. The writer's hypothesis is that these three abnormal boars were cases of auto-immunization. It is assumed that they, like other boars, produced spermatozoa continually; but, unlike the normal ones, they somehow resorbed their spermatozoa as these accumulated in the seminal vesicles or in other sexual organs, as in the testes themselves or in the epididymis. It is further assumed that as resorption took place, a parallel production of antibodies against the spermatozoa occurred. These antibodies, by continually acting upon the spermatozoa, eventually killed them. This, it may be supposed, happened when boars /61, 2703/190, and 2200/91 were not mated for a long time. Later, when they were mated often—that is, as the interval between matings was shortened—two processes took place: (*a*) less spermatozoa were resorbed and the production of antibodies diminished; and (*b*) the time during which the antibodies acted upon the spermatozoa was shortened, and their lethal action lessened.

The plausibility of this explanation is supported to some extent by Guyer (1922, 1925), who reported success in producing

sterility in rabbits, which previously had showed fertility, by injecting into them their own spermatozoa. Furthermore, by showing that if the lens of the eye is injured the animal produces antibodies against its own lens, Guyer gave a specific foundation for the idea that an animal, the rabbit, at least—under certain conditions, does produce antibodies against its own tissues. By analogy, it may be supposed that the boar upon resorption of his own spermatozoa develops auto-immunization. This would account for the nonmotile and agglutinated condition of the spermatozoa of the three boars above mentioned.

*The semen of boars under a light mating schedule.*—The following table is a summary of the data on boars under a light mating schedule:

TABLE 3.—*The age of the boars, the volume of the semen, and the density and total number of spermatozoa given during a light mating schedule.*

| Boar No. | Age. | Mated. | Volume of semen. | Spermatozoa. In 1 cmm. | Spermatozoa. Total. |
|---|---|---|---|---|---|
| | *Mos.* | | *cc.* | | $\times 10^{10}$ |
| 2782/298 | 10 | June 28 | 402 | 198,000 | 7.96 |
| | | June 30 | 217 | 502,000 | 10.89 |
| | | July 29 | 135 | 587,500 | 7.93 |
| 2784/302 | 10 | July 15 | 135 | 233,000 | 3.15 |
| | | Aug. 11 | 105 | 372,000 | 3.91 |
| | | Aug. 23 | 230 | 281,000 | 6.46 |
| 2805/330 | 10 | July 11 | 180 | 178,000 | 3.20 |
| | | July 22 | 160 | 258,000 | 4.13 |
| 2807/334 | 10 | June 28 | 175 | 143,000 | 2.51 |
| | | June 30 | 335 | 61,200 | 2.05 |
| | | Aug. 13 | 200 | 67,000 | 1.34 |
| 2688/170 | 12 | June 29 | 295 | 181,000 | 5.34 |
| | | Aug. 4 | 180 | 311,000 | 5.60 |
| | | Aug. 7 | 170 | 344,000 | 5.85 |
| 2695/178 | 12 | May 31 | 250 | 595,000 | 14.87 |
| | | June 5 | 160 | 830,000 | 13.28 |
| | | July 30 | 230 | 464,000 | 10.67 |
| 2705/194 | 12 | May 31 | 200 | 720,000 | 14.00 |
| | | June 5 | 240 | 486,000 | 11.66 |
| | | June 8 | 340 | 312,000 | 10.61 |
| 2707/196 | 12 | June 11 | 240 | 376,000 | 9.02 |
| | | Aug. 12 | 180 | 570,000 | 10.26 |
| | | Aug. 22 | 380 | 430,000 | 16.34 |
| 2709/198 | 12 | June 27 | 290 | 194,000 | 5.63 |
| | | June 29 | 120 | 598,000 | 7.18 |
| | | Aug. 2 | 250 | 184,000 | 4.60 |
| 2564/34 | 14 | June 10 | 315 | 418,000 | 13.17 |
| | | June 22 | 140 | 1,004,000 | 14.06 |
| | | July 26 | 260 | 419,000 | 10.89 |

TABLE 3.—*The age of the boars, the volume of the semen, and the density and total number of spermatozoa given during a light mating schedule*—Continued.

| Boar No. | Age. | Mated. | Volume of semen. | Spermatozoa. | |
|---|---|---|---|---|---|
| | | | | In 1 cmm. | Total. |
| | *Mos.* | | *cc.* | | $\times 10^{10}$ |
| 2485/27 | 14 | May 25 | 220 | 578,000 | 12.72 |
| | | May 29 | 350 | 294,000 | 10.29 |
| | | June 2 | 410 | 286,000 | 11.73 |
| 2486/28 | 14 | May 25 | 260 | 422,000 | 10.97 |
| | | June 13 | 235 | 193,000 | 4.54 |
| | | July 18 | 295 | 239,000 | 7.05 |
| /61 | 13 | May 25 | 175 | 372,000 | 6.51 |
| | | July 2 | 127 | 227,000 | 2.88 |
| | | July 13 | 245 | 325,000 | 7.96 |
| 2615/91 | 13 | June 9 | 315 | 338,000 | 10.65 |
| | | June 21 | 340 | 364,000 | 12.38 |
| | | June 24 | 265 | 244,000 | 6.47 |
| 2196/87 | 24 | June 1 | 410 | 31,400 | 1.29 |
| | | July 16 | 155 | 169,000 | 2.62 |
| | | Aug. 1 | 190 | 276,000 | 5.24 |
| 2200/91 | 24 | June 1 | 510 | 23,000 | 1.17 |
| | | July 3 | 420 | 92,000 | 3.86 |
| | | Aug. 1 | 310 | 263,000 | 8.15 |
| 1883/284 | 34 | May 28 | 190 | 480,000 | 9.12 |
| | | July 3 | 249 | 400,000 | 9.96 |
| | | July 17 | 540 | 253,000 | 13.66 |
| Average | | | 252.8 | 339,354.9 | 7.83 |

DISCUSSION OF DATA PRESENTED IN TABLE 3

1. There is no correlation between the volume of the semen and the total number of spermatozoa. A boar will sometimes give more spermatozoa in a small volume of semen than in a large amount. The case of boar 2200/91 is a conspicuous example. June 1 this boar gave 510 cc of semen, which contained only $1.17 \times 10^{10}$ spermatozoa. August 1 he gave a much smaller amount of semen, 310 cc, but the total number of spermatozoa was much greater, $8.15 \times 10^{10}$. The volume of the latter was three-fifths that of the former, though the latter sample contained 7.4 times as many spermatozoa as the former. In the former case the greater volume of liquid acted as a mere diluent. There are other similar cases. Boar 2709/198 June 29 gave 120 cc of semen containing $7.18 \times 10^{10}$ spermatozoa; August 2, 250 cc containing only $4.60 \times 10^{10}$. The table shows still other cases.

On the other hand, there are cases where a greater volume of semen means a greater number of spermatozoa. There is the case of boar 2707/196, to mention but one, that June 11 gave 240 cc of semen containing $9.02 \times 10^{10}$ spermatozoa; and August 22, 380 cc containing $16.34 \times 10^{10}$ spermatozoa.

The lack of correlation between the volume of semen and the number of spermatozoa carried in it compels one to consider both elements in examining the sexual potency of the boar.

2. The volume of the semen varies a great deal even in the same boar; under a light mating schedule it may range from 190 cc to 540 cc, as in the case of boar 2200/91. In Table 3 the volume of the semen varies from 105 cc to 540 cc; the arithmetic average is 252.8 cc.

3. The number of spermatozoa ejected by a boar, like the volume of his semen, varies widely. In this respect boar 2200/91 is a good example. June 1 he gave only $1.17 \times 10^{10}$ spermatozoa; July 3, $3.86 \times 10^{10}$; and August 1, $8.15 \times 10^{10}$. Other boars also showed a great deal of variation, though not as much as that shown by boar 2200/91. The table as a whole shows a range of variation from $1.17 \times 10^{10}$ to $16.34 \times 10^{10}$, the arithmetic average being $7.83 \times 10^{10}$.

The number of spermatozoa contained in the semen is very important, because the number of functional spermatozoa that a boar gives in one ejection is a measure of his fecundity—fecundity being defined as the ability of producing functional gametes. This definition of fecundity suffers from the indefiniteness of the term "functional." For present purposes, until the different factors constituting what must be meant by this term "functional" have been studied, it must be assumed that a functional spermatozoa is one that is actively moving forward in the normal rotatory manner. From a practical standpoint, the knowledge of the fecundity of a boar is important because a boar that produces relatively few functional spermatozoa (a boar of poor fecundity) is more likely to have poor fertility, and therefore may be safely discarded. Knowing the fecundity of a boar one can foretell his probable usefulness as a breeder.

It is assumed that there is a fairly close correlation between fecundity and fertility. This assumption is based on what is known to happen to the spermatozoa in the uterus after insemination, at least in the case of some laboratory animals. Yochem (1929) presents data to show that the number of spermatozoa in the genital tract of the guinea pig is reduced greatly

in the course of twenty-four hours, and that the leucocytes seem to be largely responsible for this. It is, of course, a common fact that during estrum the uteri of all animals so far studied contain in their lumen great numbers of leucocytes. Although the writer's evidence is not as yet conclusive, he has made some observations which tend to show that this phenomenon of the spermatozoa being consumed by the leucocytes takes place also in the sow's uterus. These side lights make it more possible to understand clearly the rôle played by the great numbers of spermatozoa that a boar gives in one ejection: the greater the number of spermatozoa the greater the probability that enough spermatozoa will survive the action of the leucocytes to fertilize the ova. Herein, therefore, is one factor that acts to correlate fecundity and fertility.

4. The density of the spermatozoa varies a great deal, even in the same individual. To take two well-marked examples: Boar 2196/87 showed a density of 31,400 spermatozoa per cubic millimeter June 1, 169,000 July 16, and 276,000 August 1. Boar 2200/91 gave a similar record: June 1 he gave 23,000 spermatozoa per cubic millimeter, July 3, 92,000, and August 1, 263,000. Taken as a whole Table 3 shows that the variation ranges from 23,000 to 1,004,000 spermatozoa per cubic millimeter. The arithmetic average is 339,354.9 spermatozoa per cubic millimeter.

The density of spermatozoa in the semen is very important. Unless the volume of the semen is very large, small density means a small total number, and this means, from the above definition, poor fecundity. There are at least five factors to which poor density may be attributed; namely, (*a*) failure of the boar to mate normally, which may mean the secretion of a large amount of the first two secretions, (*b*) some physiological abnormality of the boar, (*c*) sexual immaturity, (*d*) senility, (*e*) poor fecundity. The first four may easily be ruled out.

5. The age of the boar is of course a factor in the production of semen. As stated above, of the six 10-month-old boars that we had in the experiment, we succeeded in getting only four to mate. From the standpoint of both the average of the density and the total number of spermatozoa, boar 2807/334 gave poor samples of semen, and so did two other young boars. Boar 2782/298, on the other hand, by giving good samples of semen (from the above standpoint) was clearly an exception among the young animals.

As to the average of the density and of the total number of spermatozoa, it was found that the 12- and 14-month-old boars almost always gave good semen. Not all mature boars, however, produced good semen. Despite the fact that his semen was more voluminous than the average sample, boar 2200/91 gave such a low density of spermatozoa that the total number was far below the average. This was true in two of the three samples cited. In the third case the boar gave a density and total number of spermatozoa that was higher than the average. Boar 2196/87 failed to give a sample of good semen in the three cases mentioned in the table. A 12-month-old boar, 2688/170, like the last two, failed also to give semen that contained the average total number of spermatozoa.

It appears from the above table that, as a general rule, 10-month-old boars fail to produce as much spermatozoa as mature boars—1.5-year-olds, for instance—though the number of young boars studied was small, and the data are too meager to warrant dogmatic statements about the use of young boars as breeding animals. From the available data one may merely infer that it is probably not wise to breed 10-month-old boars. Not only did some of the young boars fail entirely to mate when tried, but the ones that did mate, except one, failed to produce the average total number of spermatozoa. We must also bear in mind the common knowledge that breeding a young animal tends to retard its growth.

On the effect of old age upon the production of spermatozoa no data were obtained. A study of this problem not only would shed light upon the sexual life of the boar, but also determine how long and to what age the boar may be kept profitably for breeding purposes.

*The semen in intensive mating.*—By intensive mating is meant, in these studies, mating a boar once every day for five or more consecutive days for a period of seven days.

*Mating once a day for five consecutive days.*—We tried to get as many boars as possible to mate daily for five consecutive days, but of the ones tried only those in Table 4 responded, and only two of these really fulfilled the schedule of mating. Probably boars 2485/27 and 2486/28 would have responded well too, but we could not try them because they were on a heavier mating schedule.

TABLE 4.—*Boars mated once a day for five consecutive days.*

| Boar No. | June 21. | | | June 22. | | | June 23. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Volume of semen. | Spermatozoa per cmm. | Total spermatozoa. | Volume of semen. | Spermatozoa per cmm. | Total spermatozoa. | Volume of semen. | Spermatozoa per cmm. | Total spermatozoa. |
| | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ |
| 2805/330 | ------ | (a) | -------- | 160 | 258,000 | 4.13 | 160 | 360,000 | [b] 5.76 |
| 2695/178 | ------ | (a) | -------- | 289 | (b) | -------- | 315 | 444,000 | 13.98 |
| 2615/91 | 340 | 364,800 | 12.4 | 180 | 382,000 | 6.87 | ------ | (c) | -------- |
| 2564/34 | ------ | (a) | -------- | 140 | 1,004,000 | 14.06 | 120 | 506,000 | 6.08 |

| Boar No. | June 24. | | | June 25. | | | June 26. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Volume of semen. | Spermatozoa per cmm. | Total spermatozoa. | Volume of semen. | Spermatozoa per cmm. | Total spermatozoa. | Volume of semen. | Spermatozoa per cmm. | Total spermatozoa. |
| | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ |
| 2805/330 | 180 | 140,000 | 2.59 | 200 | 259,000 | 5.18 | 245 | 138,000 | 3.38 |
| 2695/178 | 140 | 420,000 | 5.88 | ------ | (c) | -------- | ------ | (c) | -------- |
| 2615/91 | 265 | 244,000 | 6.46 | 175 | 155,000 | 2.71 | ------ | (c) | ------ |
| 2564/34 | 140 | 346,000 | 4.84 | 187 | 278,800 | 5.21 | 180 | 163,000 | 2.94 |

[a] Not mated. [b] Few spermatozoa; alkaline reaction. [c] Did not mate.

Table 4 shows that the boars gave great numbers of spermatozoa almost invariably on the first day of the mating period, and that the numbers fell off in the course of the period. Boar 2564/34 on the first day gave $14.06 \times 10^{10}$ spermatozoa, a very high number. On the second day the number was less than 50 per cent of that given on the preceding day, being $6.08 \times 10^{10}$. On the third day there was a further drop, and although there was a little rise on the fourth day, there was a very decided drop on the fifth day, the number being only $2.94 \times 10^{10}$, one-fifth the number given on the first day. With boar 2615/91 the results were the same. June 21 he gave $12.4 \times 10^{10}$ spermatozoa; the next day $6.87 \times 10^{10}$; after a day of rest—on the 23rd he failed to mate—he gave again $6.46 \times 10^{10}$ on the 24th; and lastly, on the 25th, he gave only $2.71 \times 10^{10}$. The 10-month-old boar 2805/330, on the other hand, gave a slightly different performance. The total number of spermatozoa given by him was well maintained. On the first day he gave only $4.13 \times 10^{10}$, considerably less than the average of normally mated boars, but there was a rise on the second day, then a bad drop on the third day, another rise on the fourth day, and another drop on the fifth day. On the whole, one can say that the tendency is for the number of spermatozoa to drop in the course of the period of daily mating.

TABLE 5.—*Boars double mated every other day.*

| Boar No. | Time of day. | July 2. | | | July 3. | | | July 4. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Volume of semen. | Spermatozoa. | | Volume of semen. | Spermatozoa. | | Volume of semen. | Spermatozoa. | |
| | | | In cmm. | Total. | | In cmm. | Total. | | In cmm. | Total. |
| | | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ |
| 2485/27 | a. m. | 230 | 351,000 | 8.08 | -------- | (b) | -------- | 160 | 163,400 | 2.61 |
| | p. m. | 120 | 122,500 | 1.47 | -------- | -------- | -------- | 145 | 85,400 | 1.23 |
| 2486/28 | a. m. | 260 | 298,000 | 7.75 | -------- | (b) | -------- | 220 | 138,600 | 3.05 |
| | p. m. | 150 | 175,800 | 2.64 | -------- | -------- | -------- | 240 | 95,200 | 1.40 |
| 2196/87 | a. m. | -------- | (a) | -------- | 280 | (c) | -------- | -------- | (b) | -------- |
| | p. m. | -------- | -------- | -------- | 160 | 56,800 | 0.91 | -------- | -------- | -------- |
| 1883/284 | a. m. | -------- | (a) | -------- | 249 | 400,000 | 9.93 | -------- | (b) | -------- |
| | p. m. | -------- | -------- | -------- | -------- | (c) | -------- | -------- | -------- | -------- |
| 2200/91 | a. m. | -------- | (a) | -------- | 420 | 43,600 | 1.83 | -------- | (b) | -------- |
| | p. m. | -------- | -------- | -------- | -------- | (c) | -------- | -------- | -------- | -------- |

| Boar No. | | July 5. | | | July 6. | | | July 7. | | | July 8. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Volume of semen. | Spermatozoa. | | Volume of semen. | Spermatozoa. | | Volume of semen. | Spermatozoa. | | Volume of semen. | Spermatozoa. | |
| | | | In cmm. | Total. | | In cmm. | Total. | | In cmm. | Total. | | In cmm. | Total. |
| | | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ | *cc.* | | $\times 10^{10}$ |
| 2485/27 | a. m. | ------- | ------- | ------- | 170 | 73,000 | 1.24 | ------- | ------- | ------- | 170 | 151,000 | 2.56 |
| | p. m. | ------- | ------- | ------- | 105 | 85,000 | 0.89 | ------- | ------- | ------- | 135 | 130,000 | 1.76 |
| 2486/28 | a. m. | ------- | ------- | ------- | 210 | 65,000 | 1.36 | ------- | ------- | ------- | 130 | 145,000 | 1.85 |
| | p. m. | ------- | ------- | ------- | 240 | 41,000 | 0.96 | ------- | ------- | ------- | 80 | 6,200 | 0.005 |
| 2196/87 | a. m. | 395 | 219,000 | 8.65 | ------- | (b) | ------- | 370 | 37,200 | 1.37 | ------- | ------- | ------- |
| | p. m. | 360 | 35,000 | 1.26 | ------- | | ------- | ------- | (d) | ------- | ------- | ------- | ------- |
| 1883/284 | a. m. | 210 | 211,000 | 4.43 | ------- | (b) | ------- | ------- | (d) | ------- | ------- | ------- | ------- |
| | p. m. | 230 | 221,000 | 5.08 | ------- | | ------- | ------- | ------- | ------- | ------- | ------- | ------- |
| 2200/91 | a. m. | 360 | 92,000 | 2.39 | ------- | (b) | ------- | ------- | (d) | ------- | ------- | ------- | ------- |
| | p. m. | ------- | (d) | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- | ------- |

[a] Not mated. [b] Rest. [c] No spermatozoa; alkaline secretion. [d] Failed to mate.

Besides this reduction of the number of spermatozoa, which may be utilized as an index of sexual activity, there is a corresponding diminution in the eagerness of the boar to mate. These two facts lead to the belief that it is not wise to mate a boar once every day for an extended length of time. On the basis of these data it would seem that it is probably not wise to mate a boar once a day more than two or at most three days consecutively.

*Mating twice a day every other day.*—Mating twice a day every other day is quite a heavy program—too heavy for most of the boars studied. Only two boars, 2485/27 and 2486/28, were able to stand it. They mated eight times in seven days. This is a much heavier mating schedule than once a day for five days, consecutively; for although in the former there is an intervening day of rest, the rate of doing work, when work is done, is much heavier than in the latter. When a boar is mated twice a day, he does within twelve hours the work that another that mates only once a day, does in thirty-six hours. It follows from a well-known physiological principle that, doing work at a more rapid rate, the former boar became fatigued more rapidly and took a relatively longer time for recovery than the latter, working at a slower rate.

In Table 5 a great difference is recorded between the total number of spermatozoa contained in the first and second samples of semen given on the first day of double mating. In the case of boar 2485/27, the first sample of semen contained $8.08 \times 10^{10}$ spermatozoa, and the second sample only $1.47 \times 10^{10}$. Boar 2486/28, similarly, gave in the first sample $7.75 \times 10^{10}$, and in the second sample only $2.64 \times 10^{10}$. July 4 boar 2485/27 gave only $2.61 \times 10^{10}$ and $1.23 \times 10^{10}$ in the first and second samples, respectively. As the period of double mating progressed, the samples of semen given by 2486/28 contained less and less spermatozoa. The same is true of 2485/27, except for a rise on the last day of the period. The number of spermatozoa in the second sample of semen was almost invariably much less than the number in the first sample; the exception was the second sample of semen from boar 1883/284, which contained a little more spermatozoa than the first sample of the same day, July 5.

The number of spermatozoa in the semen from the first mating after the intervening day of rest remained quite low, far below the arithmetic average given by the lightly mated boars, below also the twenty-four-hour production of the boars mated

once daily. Even if we added the spermatozoa from the first and second samples of semen collected July 4, they would not be sufficient to equal the number in the first sample of semen collected July 2. The same is true of the rest of the samples. Furthermore, we see that the double mating fails to produce as much spermatozoa as one daily mating. It seems then that the double sexual stimulus in twelve hours so strains the sexual organs that it takes the animal a relatively much longer time to recover his powers of ejecting mature spermatozoa.

## DISCUSSION OF INTENSIVE MATING

*The number of spermatozoa.*—In all the foregoing the only criterion has been the number of spermatozoa ejected in each mating. Obviously, this criterion is far from being complete or adequate, for it takes into account only one of the products of sexual activity. The lack of an adequate criterion itself speaks eloquently of the general ignorance about the biology of the boar. That adequate criterion is yet to evolve from future work, and herein are indicated some of the things to be studied in order that it may eventually be fully worked out.

For the time being, at least, the preliminary use of the total number of spermatozoa as a criterion for judging the effects of intensive mating upon the boar is justified to this extent: in intensive mating the testes are the most important organs responding directly to the stimulus of mating, and the number of spermatozoa is the product of the response. One way of studying the effect of intensive mating consists in determining the number of spermatozoa ejected during intensive mating and comparing the number with the average number given during light mating.

By using this criterion in examining the data on intensive mating some light may be shed on a few of the "don'ts" in the use of the boar. Only in the most exceptional cases may it be considered wise to mate a boar twice a day. In the first place, the number of spermatozoa given in the second sample of semen is far below the average given by lightly mated boars, and meagerness in the number of the spermatozoa is highly undesirable. As pointed out, the probability that enough spermatozoa for fertilization would survive the action of the leucocytes in the uterus is much smaller when the spermatozoa are few than when they are many. In the second place, the second mating apparently so strains the sexual organs that a much

longer period of rest is afterwards needed by the boar for sexual recuperation.

For the same reason it is not wise to mate a boar once every day for more than two days in succession, for even by the third day the number of spermatozoa falls far below the average number given in a light mating.

The question arises, why does the second mating in a day give only a very meager amount of spermatozoa; the epididymes apparently contain more spermatozoa than can be ejected in several ejections. It would seem as if the spermatozoa required a certain minimum length of time outside the testes, in the epididymes, to be transformed from the nonmotile type that they are when they get out of the testes into the epididymes to the motile types found at the caudal portion of the epididymes.

## SOME BIOLOGICAL FACTORS THAT INFLUENCE MATING

Assuming that the conformation of the boar is not abnormal, the following factors must be considered important in influencing the mating of the boar:

*The amount of sexual secretion.*—This factor is important, because the amount of energy consumed in the production of a secretion is at least directly proportional to the amount of the given secretion; that is, the greater the amount of the secretion the greater the amount of energy spent in producing it. It has been pointed out that in a light mating schedule the average volume of the semen is 252.8 cc. In some cases that volume reached 500 cc, and in one case it reached 540 cc. Such a voluminous secretion tends to upset some physiological balance, especially if the mating is done often.

To examine the reasons for this assertion, the sexual secretion may be divided into three main constituents: (*a*) the spermatozoa, (*b*) the nonliving organic matter in suspension (proteins, carbohydrates, and lipoids), and (*c*) the mineral matter.

*The spermatozoa.*—Table 4 shows that some boars are able to eject as many as $5.18 \times 10^{10}$ spermatozoa within twenty-four hours, provided the daily matings are not prolonged. Lightly mated boars give an average of $7.83 \times 10^{10}$ spermatozoa, and the number may be as high as $16.34 \times 10^{10}$. The production of such a great number of spermatozoa, which means the elaboration of a relatively large amount of complex substances, like the nucleo-proteins, undoubtedly uses up a great deal of energy.

The importance of the number of spermatozoa becomes somewhat clearer if a comparison be made between the total number

of spermatozoa ejected by the boar and that by the ram. The ram's semen is very dense with spermatozoa, there being about $2.0 \times 10^9$ per cubic centimeter, or a total of $2.0 \times 10^9$ to $4.5 \times 10^9$ in 1 cc to 1.5 cc, which is the normal volume of the ram's semen.[2] The average number of spermatozoa in the boar's semen is $7.83 \times 10^{10}$ or $78.3 \times 10^9$. The boar's semen, therefore, contains about 19 times as many spermatozoa as the semen of the ram—assuming $3.75 \times 10^9$ as the average number of spermatozoa in the ram's semen. The ram, then, would have to mate 19 times in order to produce the number of spermatozoa given by the boar in one ejection—that is, assuming that the ram gives $3.75 \times 10^9$ spermatozoa in each successive ejection, which is highly improbable.

The great number of spermatozoa ejected, the production of which takes a great amount of energy, is one of the important reasons why a boar cannot mate normally more than twice a day at most.

*The organic substances in the semen.*—If it is assumed that the amount of organic substance per cubic centimeter of semen does not vary much, it would follow that the greater the volume of the semen the greater the amount of organic substances; there would, in fact, be a linear relation between the volume of semen and the amount of organic substances. The importance of the organic substances is evidently in the amount of energy the boar has to spend in elaborating them; the more organic substances there are, the greater the amount of energy needed to produce them, and the more easily the boar gets exhausted. Among the domestic animals the boar gives the greatest volume of semen, and probably secretes the greatest amount of organic substances in the semen.

*The inorganic substances in the semen.*—It is probable that the amount of salts in the semen varies little, for if it varied much the osmotic pressure would likewise vary, and this would kill the spermatozoa. In man and the stallion, Koltzoff points out that the semen contains about 0.9 per cent of salts. If the semen of the boar contained about the same concentration of salts, the average volume of semen given by a lightly mated boar, 252.8 cc, would contain 2.3 grams of salts, and a 500-cc sample 4.5 grams.

[2] The information on the average number of spermatozoa in the semen of the ram was furnished the author by Mr. V. K. Milovanoff, of the Institute of General Animal Husbandry, Moscow.

Two and three-tenths grams of minerals by itself is not much, but when this amount is compared with the quantity that is probably present in the semen of the ram, the horse, or the bull, it is large. Assuming that the semen of all these animals contains 0.9 per cent of salts, the ram would give only 0.0135 gram in 1.5 cc of semen; the bull, 0.0405 in 4.5 cc (the average volume of a bull's semen); and the horse, 0.45 gram in 50 cc (the average volume of the stallion's semen).[3]

It is clear, that the relatively large amount of salts in the semen of the boar probably influences his mineral metabolism. Mating probably upsets the mineral balance in the boar more than in the males of any other species of domesticated animal. This is probably especially true in the case of an intensively mated boar. Therefore, the study of this factor should prove interesting and profitable.

*The amount of energy needed for mating.*—It takes the boar from five to eight minutes to complete the sexual act. This is from the time the penis is inserted into the vagina to the time the boar is ready to dismount. The ram and the bull complete the sexual act almost instantaneously with the insertion of the penis into the vagina. The stallion takes about two to three minutes to complete the act. Apparently, in animals where the development of the sexual organs is comparable, the length of time taken to complete the sexual act is a function of the amount of the semen given. The boar, giving the largest amount of semen, takes the longest time to complete the act; the stallion, ejecting the next largest amount of semen, completes the sexual act in the next longest time; the bull and the ram ejecting very little semen complete the act in a very short time.

The length of time required to complete the act can, in a way, show how much muscular and nervous energy are spent in mating. The longer it takes to complete the act, the greater the relative amount of energy consumed. Thus, the ram would consume the least relative amount of energy in mating, and the boar the largest relative amount. This is another reason for the boar's inability to mate as heavily as the ram, for instance.

## SUMMARY

1. The semen from the first mating of the boar does not as a rule give spermatozoa different from those given in subsequent

[3] The information on the relative volume of the semen of the bull, the ram, and the stallion was given to me by Mr. V. K. Milovanoff, of the Institute of General Animal Husbandry, Moscow.

matings. There were two boars, however, that gave repeatedly dead spermatozoa. It was attempted provisionally to explain this phenomenon as a case of abnormal resorption of spermatozoa and the consequent formation of antibodies against the spermatozoa.

2. The total number of spermatozoa ejected by a boar, especially in some cases, is quite variable. By considering a number of boars together, however, the average number of spermatozoa in a normal ejection can be determined. That average is $7.83 \times 10^{10}$.

3. The total number of spermatozoa given is a measure of the fecundity of the boar. This is an index of a boar's quality which may be of practical value in selection work. It was pointed out that poor fecundity probably means poor fertility.

4. There is no correlation between the volume of the semen and the total number of spermatozoa.

5. The volume of the semen as well as the density of the spermatozoa and the total number varies widely, even in the same individual.

6. From the data, it would appear that it is not wise to breed a boar until he is about 14 months old, and then only lightly. It is probably best not to mate boars intensively until they get to be around 2 years old or more.

7. It would seem as if a boar should not be mated more than once a day under ordinary conditions. Our data suggests also that a boar should probably not be mated any more than once a day for two consecutive days. And after such a period, he should be given a rest of at least two days.

8. The factors that prevent the use of the boar twice a day or more have been discussed. Fully to establish the points brought out, however, requires experimental procedure.

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## ILLUSTRATION

TEXT FIG. 1. Longitudinal section of artificial vagina.

# A NEW PHILIPPINE PHALLOID (ANTHURUS BROWNII)

By José Miguel Mendoza

*Mycologist, National Museum Division, Bureau of Science, Manila*

ONE PLATE

The Philippines are rich in phalloids, many of them interesting even to the layman. Some of the phalloids are beautiful, others have queer shapes, while from a few emanates an offensive fetid odor which can be detected from a considerable distance. While the group is well known to science, unfortunately few species of *Anthurus* have been studied critically. This is the first time this genus is reported from the Philippines. The new form herein reported and described is based on study of fresh specimens.

**ANTHURUS BROWNII Mendoza sp. nov.** Plate 1, figs. 1 to 5.

Peridium obovatum, albi coloris, circa 5 cm. in diametro, asperum, ex tribus stratis compositum quorum externum tenueque est furfuraceum, illud vero internum et crassum, gelatinosum; receptaculo stipitato, cavo, brevi, cylindraceo, longo circa 5 cm., 4 cm. in diametro, albi coloris, tenui, in brachia 6 ad 9 scisso, primo ad apiceum conjuncto, posterius vero tempore separato; superficie interna brachiorum gleba fœtida atraque ornata; sporidiis, 3.19 micra ad 4.46 micra longis, latis 2.87 micra ad 3.82 micra, congestis se tincta exhibentibus, sub microscopio vero viridis cinerei coloris.

Peridium obovate, white, about 5 cm in diameter, sometimes smaller, outer coating rough to the touch, composed of 3 distinct layers, the other being thin and furfuraceous, the inner thick and gelatinous. Receptacle stipitate, short, cylindrical, hollow, up to 5 cm long, about 4 cm in diameter, rather thin, white throughout, broader at the top than below, divided into 6 to 9 arms; arms white, 3.5 to 6 cm long, finely wrinkled on the interior, longitudinally sutured at the outside, when young the arms are united, but soon break off at the apex, several fingers are bifurcated at the extremities. Gleba borne on the inner surface of the arms, extremely fetid, black; spores are of a tinted color

when in mass, olive-gray under microscope, oval to elliptical, 3.19 to 4.46 μ long, 2.81 to 3.82 μ broad.

LUZON, Rizal Province, Muntinlupa, *Bur. Sci. 55052, E. D. Gutierrez* (type), October 15, 1932, on sandy shore of Laguna de Bay, *Bur. Sci. 55625, J. M. Mendoza,* July 20, 1933, on sandy shore, near Laguna de Bay, *Bur. Sci. 55626, J. M. Mendoza,* November 12, 1932, on sandy shore, Laguna de Bay, *Bur. Sci. 55627, J. M. Mendoza,* July 15, 1933, on sandy shore of Laguna de Bay, *Bur. Sci. 55628, J. M. Mendoza,* August 20, 1933, *Bur. Sci. 55629, J. M. Mendoza,* October 1, 1932, *Bur. Sci. 55630, J. M. Mendoza,* July 10, 1933, on sandy soil; *Bur. Sci. 55631, J. M. Mendoza,* October 25, 1933, on sandy soil.

*Anthurus brownii* resembles *A. archeri* in many respects, differing, however, in color which is white while that of *A. archeri* is red, and in having six to nine arms. *Anthurus archeri* has five to seven arms.

The species grows in sandy soil, mixed with decayed organic matter, and is found from June to about November.

The author dedicates the species to Dr. W. H. Brown, director of the Bureau of Science, for his many years of botanical work in the Philippines.

ACKNOWLEDGMENT

The writer is indebted to Dr. E. Quisumbing, botanist, National Museum Division, Bureau of Science, for criticisms.

## ILLUSTRATION

PLATE 1. ANTHURUS BROWNII SP. NOV.

FIG. 1. The phalloid in unexpanded stage; × 0.75.
2. Young stage showing the united arms; × 0.75.
3. A full-grown fungus; × 0.75.
4. The same after removing the volva; × 0.75.
5. The fungus in its natural habitat. (Photographed by Domingo Farol, of the Bureau of Science.)

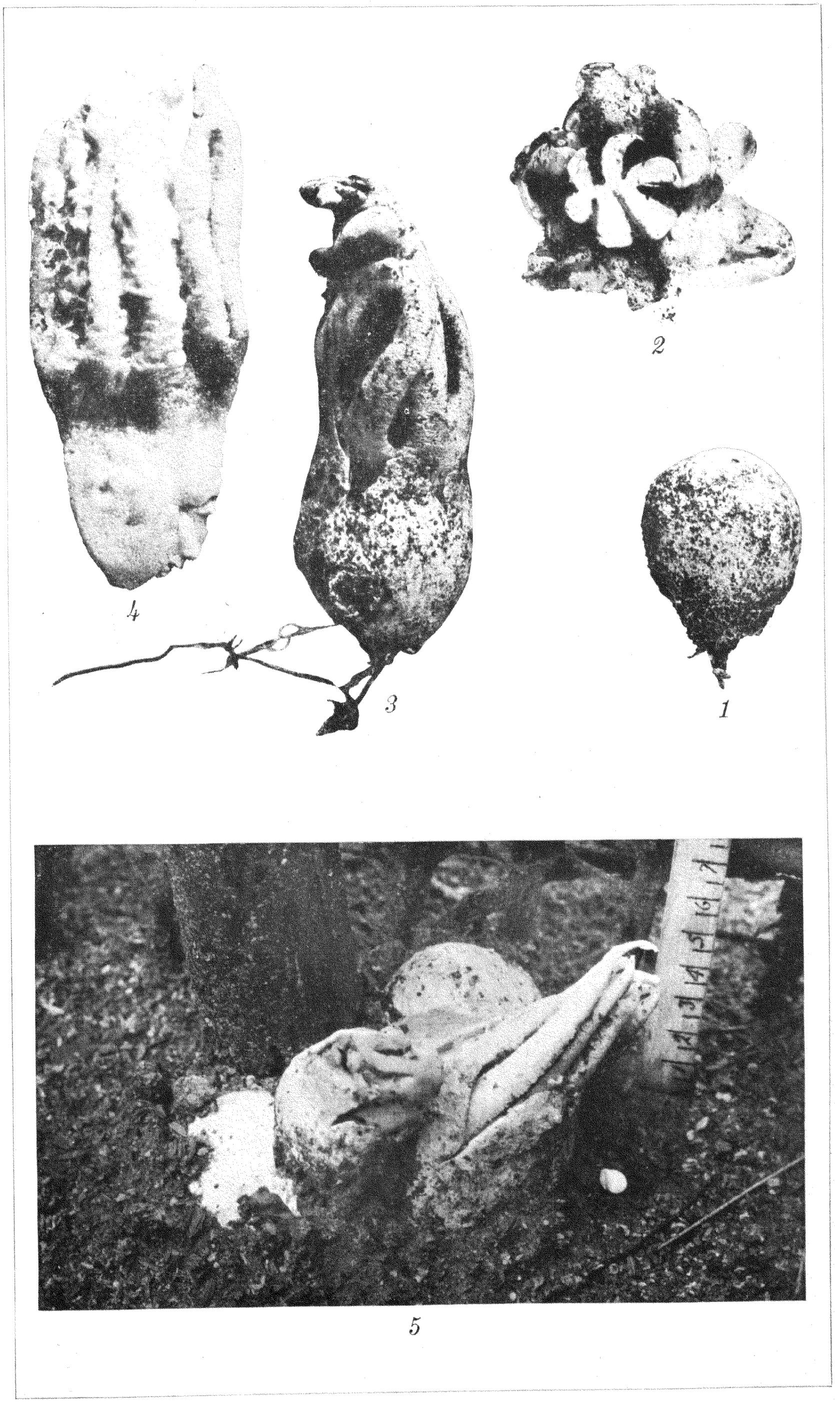


PLATE 1.

# THE PHILIPPINE JOURNAL OF SCIENCE

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## THE NUTRITIVE VALUE OF THE MOUNTAIN APPLE EUGENIA MALACCENSIS OR JAMBOSA MALACCENSIS [1]

By CAREY D. MILLER, RUTH C. ROBBINS, and KISAKO HAIDA

*Of the Nutrition Laboratory, Hawaii Agricultural Experiment Station, under the joint supervision of the University of Hawaii and the United States Department of Agriculture, Honolulu*

ONE PLATE AND THREE TEXT FIGURES

The mountain apple, *Eugenia malaccensis* or *Jambosa malaccensis,* is a fruit tree indigenous to the tropical Pacific islands and northern Australia. It was probably brought to the Hawaiian Islands by the early Polynesians and is called by the Hawaiians *ohia-ai.*

In the Hawaiian Islands, its distribution was previously much greater than now, as in some places it has been cut and in others it has died because the water supply has been diverted for agricultural purposes. From almost sea level up to 1,800 feet, the mountain apple is found growing in thick stands along the streams of sheltered valleys, especially on the windward slopes.

Many of the present trees are rather small, but they vary in height from 25 to 50 feet and have beautiful, dense green foliage and bright crimson flowers. The corolla and calyx of the flowers are insignificant in comparison with the pistil and mass of stamens. The flowers and fruit borne on thick short stems, grow from the trunks as well as from the branches. The fruit resembles an apple but tends to be somewhat pear-shaped (Plate

[1] Published with the permission of the director of the Hawaii Agricultural Experiment Station.

1). It has a thin and delicate skin of a deep crimson color and a crisp, snowy white pulp of mild flavor. There is usually a single round seed, which is covered with a brown skin. The edible portion of the mountain apple varies from 73 to 87 per cent, some of the fruits having much larger seeds than others. The fruit may be used fresh, for making fruit juices, in salads, and in cooked dishes, such as pie. Ripe fruit can usually be obtained from some part of the Hawaiian Islands from June to October, but it is usually most plentiful during July and August. Small quantities of fruit are sometimes obtainable at other times of the year.

Many inquiries have come to the nutrition laboratory of the University of Hawaii regarding the nutritive value of the mountain apple. The work here reported has been done to supply information locally, but because of the wide distribution of this fruit it is believed it will be of interest to others.

## COMPOSITION

The nutritive constituents, total acidity, and mineral elements of the fruit were determined by the methods of the Association of Official Agricultural Chemists(1) or by slight modifications of these procedures. Acid was calculated as anhydrous citric and is reported as percentage of the fresh substance. Iron was determined by the method recommended by Elvehjem and Hart.(2)

Samples for all analyses except iron and total acidity were prepared by wiping the mountain apples carefully and slicing without peeling. The stones were discarded, and the sliced edible portion was dried on enamel trays in an enamel-lined electric oven at a temperature below 65° C.

In being prepared for the iron analyses the mountain apples were peeled and cut with a new stainless-steel knife and ashed wet to avoid contamination. Separate determinations were made on the skin and on the pulp. The percentage of iron given in the table is the average of three sets of analyses; in each case the skin and the pulp were analyzed separately, and the results added. For the determination of total acidity fresh fruit was used.

The average amounts of the other constituents, obtained by analyses of two different lots of mountain apples, are summarized in Table 1, together with a previously published analysis by the Hawaii Agricultural Experiment Station.(3) The analyses show the mountain apple to be a watery fruit with

about half the sugar content of apples, and a similar amount of calcium, phosphorus, and iron.(4) Practically all of the iron is in the skin. We found that if the red skin was completely removed, the colorimetric readings for the iron of the pulp were the same as the blank determinations.

TABLE 1.—*Composition of the fruit of mountain apple.*

| Constituent. | Average of two analyses. Nutrition laboratory. | From Report of the Hawaii Agr. Expt. Station, 1914. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Moisture | 91.54 | 91.39 |
| Protein (N × 6.25) | 0.33 | 0.213 |
| Ether extract | 0.06 | 0.035 |
| Crude fiber | 0.80 | 0.562 |
| Ash | 0.26 | 0.137 |
| Carbohydrate by difference | 7.01 | ---------- |
| Acid as citric | 0.15 | ---------- |
| Reducing sugars | ---------- | 6.88 |
| Sucrose | ---------- | None. |
| Calcium | 0.007 | ---------- |
| Phosphorus | 0.013 | ---------- |
| Iron | 0.00038 | ---------- |

Although analyses show the fruit to have a high water content, it does not seem very juicy when cut. This is perhaps due to the nature of the polysaccharide present. The crude fiber, when determined by the usual methods, was found to swell much more than would be expected if it were ordinary cellulose, and to have a remarkable power of holding water. The nature of this crude fiber would bear further investigation.

The coloring matter in the skin also would be an interesting subject for investigation. It stains a deep purple everything with which it comes in contact. A dilute solution of the juice from the whole fruit prepared for the acidity determination showed a strong indicator action. The solution was distinctly pink when acid and greenish yellow when alkaline, with a definite end point.

## VITAMIN METHODS

The methods used for the quantitative determination of the vitamins were essentially those recommended by Sherman.(4) The rats were standard animals raised in our laboratory. All the usual precautions recommended for carrying out quantitative vitamin tests were followed.

Because of the short season and the uncertainty of a continuous supply of fresh fruit, the experiments here reported were done over a period of three years. Most of the experiments carried on during the first summer were of a preliminary nature and are not reported in the final summaries.

The term "daily feedings" is here used to mean feedings given every day except Sunday.

## VITAMIN A

Table 2 and fig. 1 summarize the results of feeding mountain apple as the sole source of vitamin A to twenty-six standard white rats.

TABLE 2.—*Results of feeding mountain apple as the sole source of vitamins A, B, and G.*

VITAMIN A.

| Source of vitamin. | Rats. | Weight of supplement fed daily. | Average weights. Initial. | Average weights. When supplement started. | Average weights. Final. | Average gain or loss in eight weeks. |
|---|---|---|---|---|---|---|
| | | *g.* | *g.* | *g.* | *g.* | *g.* |
| Negative control | 2 | 0.0 | 38 | ---------- | 89 | ---------- |
| Mountain apple | 9 | 4.0 | 43 | 157 | 139 | [a] —18 |
| Do | 10 | 6.0 | 43 | 158 | 197 | 39 |
| Do | 3 | 8.0 | 45 | 135 | 165 | 30 |
| Do | 4 | 10.0 | 40 | 120 | 165 | 45 |
| **VITAMIN B.** | | | | | | |
| Negative control | 2 | 0.0 | 58 | ---------- | 52 | ---------- |
| Mountain apple | 17 | 8.0 | 56 | 81 | 102 | 21 |
| **VITAMIN G.** | | | | | | |
| Negative control | 2 | 0.0 | 56 | ---------- | 70 | ---------- |
| Mountain apple | 8 | 8.0 | 52 | 71 | 110 | 39 |
| Do | 8 | 10.0 | 52 | 69 | 110 | 41 |

[a] Fed only five weeks.

The mountain apple is obviously low in vitamin A. Rats fed, respectively, 6, 8, and 10 grams of mountain apple daily grew rapidly at almost the same rate for four weeks and then started to lose weight. Four animals on 6 grams daily died at the end of five or six weeks, whereas the remaining group of animals stopped losing or gained again. There was no apparent change in the quality of the fruit at this time, and accordingly there is no simple explanation of this response of the rats to the feeding

procedure. The four rats fed 10 grams of mountain apple daily showed poor growth response the last four weeks, but their average gain for eight weeks was greater than the average gain of the groups fed 6 and 8 grams daily.

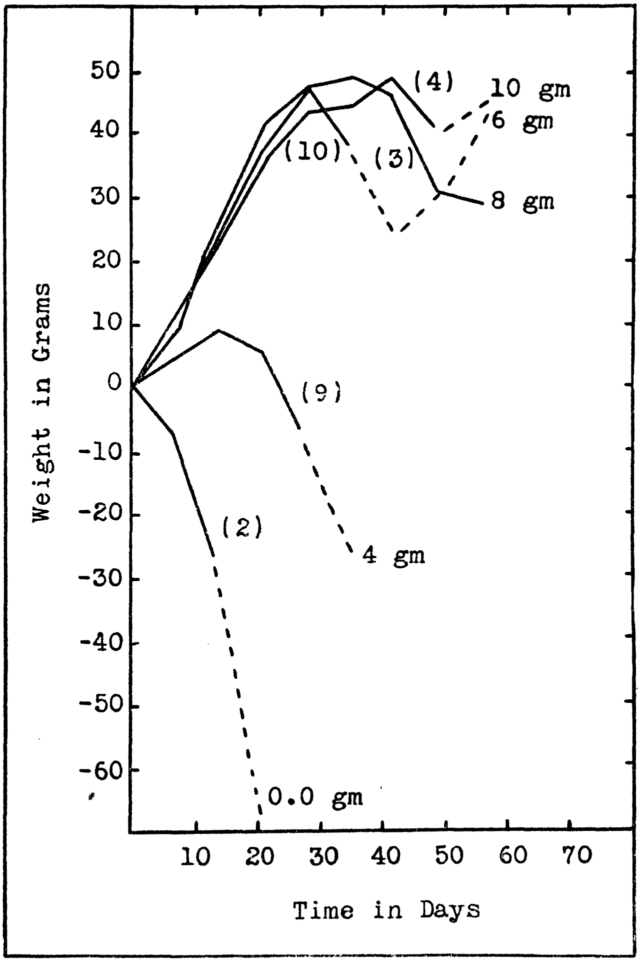


FIG. 1. Average gain in weight of groups of young rats fed varying quantities of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin A. The numbers in parentheses show the number of rats used for each test. The broken lines begin at a point indicating the occurrence of the first death in the group.

Many of the rats showed an unsteady gait with a tendency to drag the hind legs. At autopsy the rats were found to have good stores of fat in the abdominal cavity, but many symptoms of A avitaminosis were usually present. Some showed swollen

eyelids with or without bloody exudate, and some showed kidney and bladder infection. Infection of the lungs and air passages and pus at the base of the tongue was observed in some rats. On gross autopsy, the females usually showed well-developed ovaries with large ripe follicles, whereas the males showed poor sexual development. The testes were often small, and even when of nearly normal size, were abnormally dark in color. Upon microscopic examination, no motile sperms were found and in only a few were mature sperms seen.

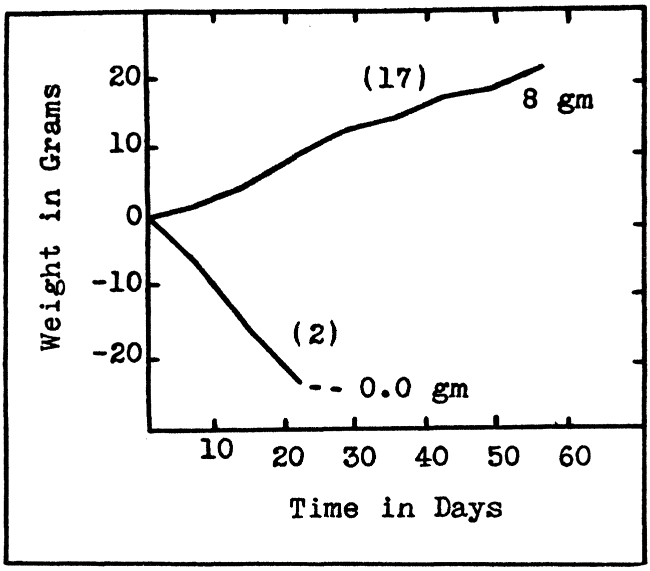


FIG. 2. Average gain in weight of young rats fed 8 grams of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin B ($B_1$). The broken line indicates the occurrence of the first death in the control group. The numbers in parentheses show the number of rats used for the tests.

VITAMIN B

Only the final tests are reported here. The results of feeding seventeen standard rats 8 grams of mountain apple daily as the sole source of vitamin B are summarized in Table 2 and fig. 2.

The average gain in eight weeks for the seventeen rats was 21 grams, but there was a great variation in the individual gains. Two rats lost 3 and 9 grams, respectively. The smallest gain was 6 grams and the greatest gain 38 grams.

At autopsy most of the rats appeared small but normal. The females showed poor sexual development; in all cases the vaginal orifices were closed and the ovaries were small or only slightly

developed. On the other hand, the males all showed well-developed testes and, upon microscopic examination, great quantities of motile sperms. These are exactly opposite to the conditions found at autopsy of the rats on vitamin-A experiments.

The mountain apple is therefore observed to be only a fair source of vitamin B.

VITAMIN G

The final results of feeding sixteen standard rats 8- and 10-gram supplements of mountain apple daily as the sole source of vitamin G are summarized in Table 2 and fig. 3.

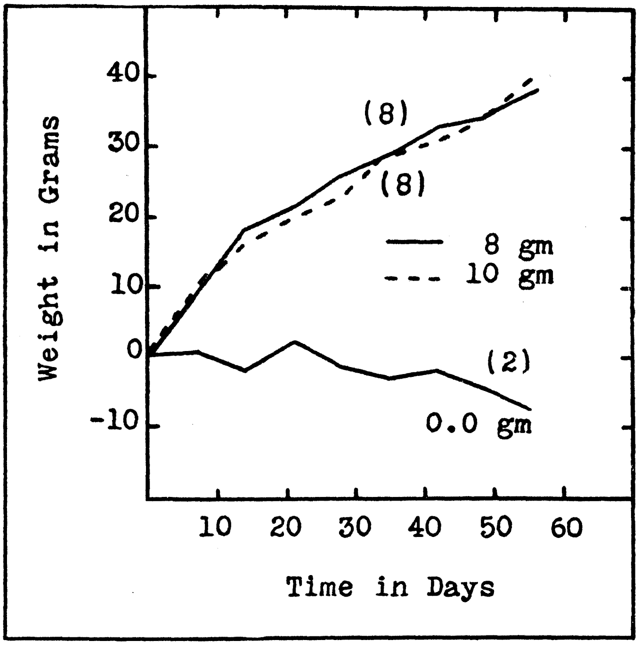


FIG. 3. Average gain in weight of groups of young rats fed 8 and 10 grams of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin G ($B_2$). The numbers in parentheses show the number of rats used for each test.

The rats in each group gained much more uniformly than those fed for vitamin B, but there was little difference in the two groups. The average gain in eight weeks for eight rats fed 8 grams of mountain apple daily was 39 grams, and that for eight rats fed 10 grams daily was 41 grams.

At autopsy all the rats showed some evidence of G avitaminosis. In our laboratory mild symptoms of low vitamin-G intake are an abnormally short, soft fur, which in some cases

is thin around the head and shoulders; blood on nose, paws, and ears, which comes from the hair follicles at the base of the whiskers; and poor sexual development. Two rats fed 10 grams of mountain apple daily showed slight necrosis of the end of their tails. Two rats in each group showed a few very small lesions. Only two male rats, one in each group, showed any motile sperms. Five female rats showed no ripe follicles, and five showed ripening or well-developed follicles. As the rats averaged 110 grams when killed, the sexual development may be related to growth and only indirectly to low vitamin G.

It thus appears that mountain apples are a fair source of vitamin G.

## VITAMIN C

Twenty-two standard guinea pigs raised in our laboratory were used to test the vitamin-C potency of mountain apples. The guinea pigs were fed Sherman's(4) scorbutic basal diet plus fresh alfalfa plus the supplements until they ate the mountain apple readily. The alfalfa was then discontinued and the mountain apple fed to the guinea pigs for the periods recorded in Table 3. At the end of the experiment the histological examination of the incisor teeth recommended by Höjer(5) was employed. The results of the experiments are summarized in Table 3.

Five guinea pigs were fed for a period of 90 days (one died after 66 days), seven were fed for 21 days, and ten were fed for 28 days. Of the three guinea pigs fed 3 grams of mountain apple daily, one died at 66 days and the other two lived out the experimental period of 90 days. All showed severe scurvy at autopsy. The two fed 5 grams for 90 days showed somewhat less severe scurvy, and the four guinea pigs fed 5 grams of mountain apple for 21 days showed slight or moderate scurvy at autopsy. Both guinea pigs fed 10 grams of mountain apple daily for 21 days showed no evidence of scurvy at autopsy. One guinea pig fed 15 grams daily showed no gross scurvy at autopsy, but the teeth were not completely protected. Six guinea pigs were fed 20 grams of mountain apple daily for 28 days and showed no signs of gross scurvy. Three had the teeth completely protected and three only partially protected. Two guinea pigs fed 25 grams of mountain apple daily for 28 days showed no gross scurvy at autopsy, but the teeth were not fully protected. Finally, two guinea pigs fed 30 grams of mountain apple daily for 28 days showed no evidence of scurvy at autopsy and the teeth were normal.

TABLE 3.—*Results of feeding mountain apple as the sole source of vitamin C.*

| Guinea pig No. | Weight of supplement fed daily. | Supplement fed. | Weight. When supplement started. | Weight. At end of experiment. | Net gain or loss. | Gross scurvy at autopsy.[a] | Histological examination of teeth, Höjer's rating.[b] |
|---|---|---|---|---|---|---|---|
| | *g.* | *Days.* | *g.* | *g.* | *g.* | | |
| 95M | 3 | 66 | 359 | 213 | —146 | +++ | ------------- |
| 99M | 3 | 90 | 347 | 326 | — 21 | +++ | ------------- |
| 103M | 3 | 90 | 334 | 285 | — 49 | +++ | ------------- |
| 62F | 5 | 21 | 356 | 344 | — 12 | ++ | 0.5 |
| 101M | 5 | 21 | 335 | 316 | — 19 | + | 0.4 |
| 64F | 5 | 21 | 334 | 322 | — 12 | + | 0.2 |
| 66F | 5 | 21 | 330 | 289 | — 41 | + | 0.2 |
| 93M | 5 | 90 | 401 | 477 | 76 | +++ | ------------- |
| 97M | 5 | 90 | 337 | 423 | 86 | +++ | ------------- |
| 68F | 10 | 21 | 308 | 295 | — 13 | — | 0.7 |
| 70F | 10 | 21 | 302 | 304 | 2 | — | 0.7 |
| 72F | 15 | 21 | 306 | 313 | 7 | — | 0.7 |
| 160F | 20 | 28 | 300 | 367 | 67 | — | 1.0 |
| 162F | 20 | 28 | 304 | 361 | 57 | — | 1.0 |
| 164F | 20 | 28 | 307 | 282 | — 25 | — | 0.7 |
| 166F | 20 | 28 | 315 | 380 | 65 | — | 0.7 |
| 168F | 20 | 28 | 315 | 421 | 106 | — | 1.0 |
| 181M | 20 | 28 | 385 | 496 | 111 | — | 0.8 |
| 170F | 25 | 28 | 312 | 286 | — 26 | — | 0.8 |
| 179M | 25 | 28 | 309 | 330 | 21 | — | 0.7 |
| 172F | 30 | 28 | 279 | 388 | 109 | — | 1.0 |
| 183M | 30 | 28 | 319 | 374 | 55 | — | 1.0 |

[a] Sherman and Smith, The Vitamins, 2d ed., 173. [b] Höjer (see bibliography).

The results indicate that the mountain apple is of relatively low antiscorbutic value.

## SUMMARY AND CONCLUSIONS

The mountain apple, *Eugenia malaccensis* or *Jambosa malaccensis,* a refreshing fruit of the tropical islands of the Pacific Ocean, has been analyzed for nutritive constituents and tested for its vitamin value.

Comparison of analyses given in Table 1 with analyses given by Sherman(4) shows that mountain apples have about half the sugar content of average apples and a higher water content than apples. The amounts of calcium, phosphorus, and iron are similar in both fruits.

Comparison of the data for mountain apples with data given by Sherman(4) for apples indicates that mountain apples are somewhat lower in all the vitamins tested and can be considered only a fair source of vitamins A, B, C, and G.

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# ILLUSTRATIONS

PLATE 1. Mountain apple; *Eugenia malaccensis*.

TEXT FIGURES

FIG. 1. Average gain in weight of groups of young rats fed varying quantities of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin A. The numbers in parentheses show the number of rats used for each test. The broken lines begin at a point indicating the occurrence of the first death in the group.

2. Average gain in weight of young rats fed 8 grams of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin B ($B_1$). The broken line indicates the occurrence of the first death in the control group. The numbers in parentheses show the number of rats used for the tests.

3. Average gain in weight of groups of young rats fed 8 and 10 grams of mountain apple, *Eugenia malaccensis*, as the sole source of vitamin G ($B_2$). The numbers in parentheses show the number of rats used for each test.


PLATE 1.

# LEPIOTA AMERICANA, AN IMMIGRANT EDIBLE MUSHROOM

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TWO PLATES

Despite the great abundance of mushrooms in the Philippines, only a few have been really tested for their edibility. While some may prove poisonous to some persons, they may prove edible to others. Of the large number of edible mushrooms, a considerable quantity goes to waste yearly during the mushroom season for lack of information about them, and the number actually reaching the family table is surprisingly small. This is especially true of the many species of *Lepiota* because some members of this genus are known to be poisonous or of a suspicious character. For example, *Lepiota chlorospora* often causes poisoning in many people, hence the mushroom collector who is familiar with this species looks askance at any mushroom that resembles it. Another species, *Lepiota cepaestipes* Fr.,[1] has been found recently by the senior author to be poisonous. Indeed, because a certain mushroom is known to be poisonous or suspected of being poisonous, the rest of its kind are often erroneously believed to be dangerous. In fact, many, including the numerous species of *Lepiota,* are palatable and safe to eat. We feel, therefore, that those mushrooms that have been found edible, especially the little known species, should be reported from time to time so that their good qualities and other characteristics may become familiar to the people. In this way we hope to add to the short list of edible mushrooms in the Philippines.

**LEPIOTA AMERICANA** Peck. Plates 1 and 2.

*Lepiota americana* PECK in New York State Cab. Rept. 23 (1871) 71; SACCARDO, Syl. Fung. 5 (1887) 43; ATKINSON, Mushrooms (1911) 80, *f. 82;* MURRILL, Mycologia 3 (1911) 168, *t. 49, f. 6;* KAUFFMAN, Agaricaceae of Michigan 1 (1918) 645.

[1] This poisonous mushroom will be reported in a separate paper.

Pileus [2] white, becoming dark brown on maturity, 5 to 14 cm broad, convex, umbonate to subumbonate at maturity, when young somewhat conical; cuticle at first reddish brown and continuous, soon breaking into scales except at the umbo; scales scattered, appressed; margin somewhat inrolled, striate, laciniate; when bruised entire plant turns pinkish to reddish brown. Gills free, white, broad, 7 to 9 mm wide. Stipe hollow, white, becoming brown in age, enlarged at the base, tapering upward, 6 to 11 cm long, 9 to 15 mm in diameter at the base, slender above the ring, 7 to 10 mm in diameter. Annulus broad, very conspicuous, 1.3 to 2.2 cm wide, 1.6 to 2.5 cm from the pileus. Basidia clavate, granular when young; granules disappearing in age, bearing 4 slender sterigmata, 18 to 30 μ long, 8.4 to 10.5 μ broad, average 24.6 μ long, 9.1 μ wide. Spores subellipsoid guttulate, smooth, hyaline, measuring from 8.5 to 10.5 μ long, 5.0 to 7.2 μ broad, average 9.9 μ long, 6.25 μ broad.

LUZON, Manila, Pandacan, *Bur. Sci. 55119, J. M. Mendoza,* July 29, 1933, on the ground, *Bur. Sci. 55137, 55139, J. M. Mendoza,* July 24, 1933, on the ground, *Bur. Sci. 55209, J. M. Mendoza,* July 25, 1933, on the ground, *Bur. Sci. 55586, J. M. Mendoza,* August 1, 1933, on the ground, *Bur. Sci. 55768, P. S. Gener,* November 7, 1933, on the ground.

*Lepiota americana* Peck resembles closely in shape a poisonous Philippine species, *L. chlorospora* Copel., particularly in the button stage. *Lepiota chlorospora,* however, has green spores, making the gills look greenish.

This mushroom came to the notice of the senior author in February, 1933, when a sample batch was referred by a member of the staff of the College of Medicine, University of the Philippines, to the Bureau of Science to find out whether or not it was edible. There was doubt in the beginning as to the edibility of this mushroom, since it resembles *Lepiota chlorospora,* which is a poisonous species. The sample was bought in Paco Market, Manila. Following the source of the purchase, it was found that this mushroom had been collected in Pandacan, Manila, in a place which had been filled in with all kinds of refuse, generally mixed with discarded straw and manure taken from United States Army stables. It seems that this mushroom is not well known even in that vicinity, for only one family in that neighborhood collects it in baskets every morning to sell

[2] The following description is based on fresh full-grown specimens collected during the mushroom season.

at Paco Market. To test the edibility of this mushroom a few were cooked in the Bureau of Science laboratory. The mushroom was found delicious and a bit peppery. On several occasions later, from time to time, the mushroom was cooked in the laboratory, and several members of the staff ate it with their other food. In taste it is comparable to any of our most delicious mushrooms. This mushroom, because of its white spores unlike *Volvaria esculenta* and *Psaliotas* which have colored spores, has the advantage of not turning the soup black or dark brown on being cooked. It keeps well in the dried form, and when soaked in water before being cooked it somewhat resumes its original form. During the numerous collecting trips made by the senior author, he has never seen this kind of mushroom. Possibly it was accidentally brought into the Philippines from abroad with animal feed, such as hay, for United States Army horses.

It is abundant during May to as late as February.

# ILLUSTRATIONS

PLATE 1. LEPIOTA AMERICANA PECK

FIG. 1. The mushroom in natural habitat, showing different stages. (Photographed by Domingo Farol of the Bureau of Science.)

2. The mushroom as sorted ready for the market. (Photographed by Domingo Farol of the Bureau of Science.)

PLATE 2. LEPIOTA AMERICANA PECK

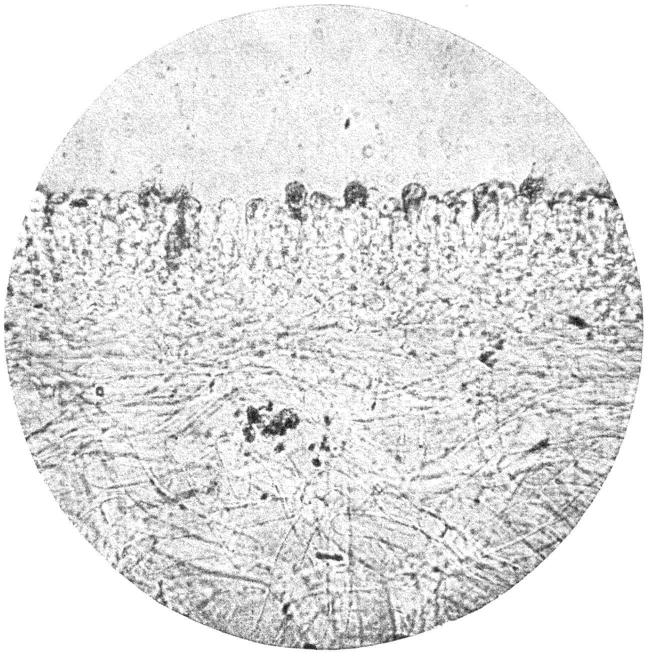
FIG. 1. Photomicrograph of a section of the gill, showing the hymenium with basidia; × 235.

2. Photomicrograph of the spores, from spore collection; × 433.

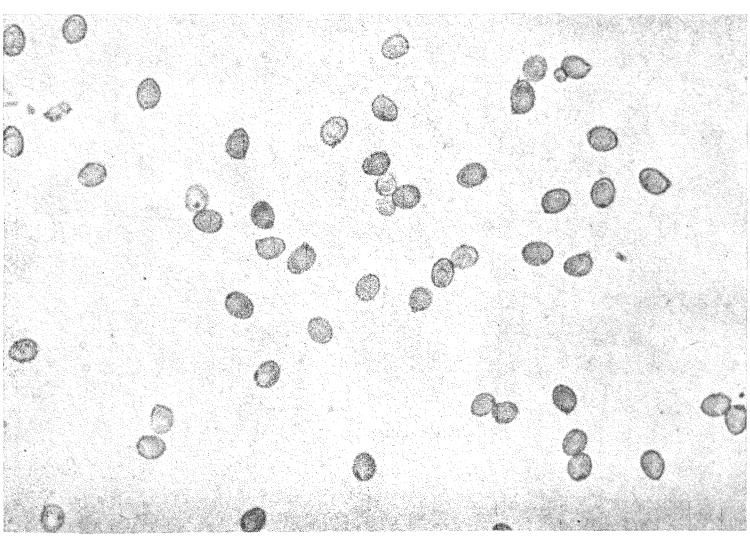
1

2

PLATE 1.



*1*



*2*

PLATE 2.

# THE DISTRIBUTION OF BANANA WILT

By Otto A. Reinking

FIVE PLATES

## INTRODUCTION

During the period 1925 to 1927, while the writer was making a study of the various banana varieties in the world, an opportunity presented itself to study the distribution of banana wilt (Panama disease) caused by *Fusarium cubense.* Former investigations relative to distribution indicated that the disease was world-wide, but authentic determination of the causal organism had not been made in all cases. The present studies were carefully checked with isolation and fungus determinations based on recent reports.(9, 11, 16) Up to the time of this investigation the disease had been recorded, outside of the Caribbean region, from Hawaii by Higgins,(7) Carpenter,(5) and Wilcox;(15) from the Philippines by Lee and Serrano;(8) from India by Basu,(1) Butler,(3) and Shaw;(12) from Australia by Tryon;(13) and from the Canary Islands and Africa by Dunlap through the Imperial Bureau of Mycology.(18, 19)

## SCOPE OF PRESENT STUDIES

Investigations on banana wilt were made by the writer in the following countries: Philippine Islands, French Indo-China, Straits Settlements (Singapore and Penang), Federated Malay States, Siam, Dutch East Indies, Australia, Burma, and India. The disease was observed in all of these countries except French Indo-China. It is highly probable that it is present in the latter country, although it was not encountered during the survey. Special studies verified its presence in the localities given in Table 1.

## DETAIL OF INVESTIGATIONS

A detailed account of the investigations, according to the countries where the disease was found, the varieties affected, and the studies made of it, is presented in the following discussion.

TABLE 1.—*Banana wilt (Panama disease); geographic distribution of diseased plants studied.*

| Country. | Locality. | Date of observation. | | Culture studies. |
|---|---|---|---|---|
| Philippine Islands | Los Baños, Laguna | Mar., | 1925 | *F. cubense* isolated. |
| Straits Settlements | Singapore | Oct., | 1925 | Do. |
| Do | Penang | Dec., | 1925 | No isolation. |
| Federated Malay States | Serdang | Dec., | 1925 | *F. cubense* isolated. |
| Do | Kuala Lumpur | Dec., | 1925 | No isolation. |
| Do | Kajang | Dec., | 1925 | Do. |
| Siam | Bangkok | Nov., | 1925 | *F. cubense* isolated. |
| Dutch East Indies | Buitenzorg, Java | Mar., | 1926 | No isolation. |
| Do | Pasar Minggoe, Java | Apr., | 1926 | *F. cubense* isolated. |
| Do | Tohoedan Experiment Station, Solo, Java. | Apr., | 1926 | No isolation. |
| Do | Pasoeroean, Java | Apr., | 1926 | Do. |
| Do | Banda, Molucca Islands | Aug., | 1926 | Do. |
| Australia | Brisbane (Pinkenba) | Oct., | 1926 | *F. cubense* isolated. |
| Burma | Hmawbi Experiment Gardens, near Rangoon. | Dec., | 1926 | No isolation. |
| India | Poona, Bombay Presidency | Jan., | 1927 | *F. cubense* isolated. |
| Do | Munsiganj, Dacca, Bengal | Jan., | 1927 | Do. |
| Do | Rampal, Dacca, Bengal | Jan., | 1927 | Do. |

## PHILIPPINE ISLANDS

The disease was first noted by Lee and Serrano (8) as being severe on the Latundan variety. Culture studies made by the writer also proved the disease to be due to *Fusarium cubense.*

### BANANA VARIETY AFFECTED

#### 1. Latundan

During March, 1925, studies of the disease situation were made by the writer. The Latundan variety was the only one observed to be affected. This banana is a common type with a world-wide distribution. In the West Indies a type of the variety is commonly known as the Apple or Manzana banana. In the Philippines this banana is most commonly planted for commercial purposes. The disease was observed only in the Manila region, indicating that it may have been introduced into the Islands. It was observed in its characteristic form in Calamba, Pansol, Lalakay, Los Baños, and Calauan, all in Laguna Province, Luzon. In some plantings 100 per cent infection was noted.

The characteristic wilting and yellowing of leaves along with severe splitting of the pseudostem characterized the disease (Plate 1, fig. 1). Interior symptoms, including the typically discolored vascular bundles, were present in each case. Cul-

ture studies showed that in all cases of disease typical *Fusarium cubense* was present in a pure state, thereby corroborating the finding of Lee and Serrano.

### STRAITS SETTLEMENTS AND FEDERATED MALAY STATES

Up to the time of this investigation the banana-wilt disease had never been reported from these regions. Studies made from October to December, 1925, showed the disease to be present in the Straits Settlements on Singapore Island (10) and in the environs of Penang, and in the Federated Malay States at Kuala Lumpur, Serdang, and Kajang. It undoubtedly is widespread throughout the Federated Malay States wherever the susceptible varieties are planted. Recent studies made by Ward (14) apparently confirm these findings.

#### BANANA VARIETIES AFFECTED

1. Awak; Penang.
2. Embun; Singapore and Kajang.
3. Rastali; Penang, Kuala Lumpur, and Serdang.

The Embun variety is commonly and severely attacked (Plate 1, fig. 2; Plate 2, fig. 1). This banana is the common Gros Michel of commerce universally planted in the West Indies. Pisang rastali is similar to the Latundan variety of the Philippine Islands and the Apple or Manzana variety of the West Indies. The Awak variety is similar to the Nam Wa of Siam. It is commonly cultivated in Penang and in various parts of the Federated Malay States. External and internal symptoms of disease on all varieties were typical of the true banana wilt of the Caribbean region. Isolations made from specimens collected at Serdang and Singapore resulted in pure cultures of *Fusarium cubense*. In no cases of typical disease were other species of fusaria isolated.

### SIAM

Banana wilt never had been reported as occurring in Siam. Observations made in November, 1925, showed the disease to be widespread and severe on one variety grown about Bangkok.

#### BANANA VARIETY AFFECTED

1. Nam Wa.

The Nam Wa variety is the commonest on the market and in the field. It is a starchy type that is usually cooked. The disease shows typical symptoms of wilting, but splitting of the pseudostem was not so common (Plate 2, fig. 2). Frequently plants appear to be partially resistant and trying to throw off

the trouble. The disease was found on a trip into the Bang Sorn district and at the Bangkok Noi Experimental Orchard just out of Bangkok. Specimens were collected and taken to the Pasteur Institute for examination and culture studies. Microscopic examination showed the typical discolored vascular bundles and mycelium in the xylem tissue. Isolation from diseased portions produced pure cultures of *Fusarium cubense.*

## DUTCH EAST INDIES

A special investigation of banana wilt was made in Java because of previous studies conducted by Gaumann(6) on a widespread vascular disease of bananas attributed to bacteria. Gaumann, in his study of this disease, failed to isolate *Fusarium cubense.* He isolated six other species of fusaria from old diseased material, but none of these produced disease in inoculation tests. At no time was one predominating fusarium found. Gaumann concludes that the vascular disease of the bananas in Java was caused by *Pseudomonas musæ* and that the genuine destructive Panama disease is similar but distinguished by the presence of *F. cubense* in the secondary vascular bundles.

In the recent study of the vascular diseases of banana in Java made by the writer the typical banana wilt (Panama disease) caused by *Fusarium cubense* was observed. External and internal symptoms were typical of those described by Brandes(2) in the West Indies. *Fusarium cubense* was isolated in pure culture from all typical cases of disease. Many banana varieties were found to be susceptible to disease, while on the other hand many resistant varieties exist.

### BANANA VARIETIES AFFECTED

*Pasar Minggoe, Java. Ragoenan Agricultural Experimental Station (near Batavia).*

1. Ambon bodas.
2. Ambon poetih (Gros Michel) (Plate 3, fig. 1).
3. Besi.
4. Boeboejan.
5. Kepok koening.
6. Kloetoek soekoen.
7. Kool.
8. Mentek.
9. Poelo alar.
10. Radja.
11. Radja djawa.
12. Radja koesta.
13. Radja pakoewon (Plate 3, fig. 4).
14. Radja pelilit.
15. Radja pretel.
16. Radja sereh bodas (Latundan, Philippines).
17. Radja sijem (Nam Wa, Siam).
18. Sembot.
19. Silo Kapoek.
20. Soesoe (Plate 3, fig. 3).
21. Songgroito (Sri) (Plate 3, fig. 2).
22. Sribali (Gros Michel type).
23. Tjandi.
24. Tjeleket.
25. Tjoemet.

*Buitenzorg, Java. Tjipakoe Experiment Station.*

1. Radja.

*Solo, Java. Tohoedan Experimental Station.*

1. Galigis.
2. Kapas idjo.
3. Kepok ambon.
4. Panggra.
5. Sobo kepok.
6. Sobo madoera.
7. Soesoe.
8. Soesoe bodas (Latundan, Philippines).

*Pasoeroean, Java. Pasoeroean Experimental Station.*

1. Gading.
2. Gembang.
3. Kapas idjo.
4. Panggra.
5. Radja djawa.

*Moluccas. Banda Islands (Banda Neira and Poeloe Ay).*

1. Radja (Ambon poetih) (Gros Michel).
2. Soesoe (Latundan, Philippines).

Possibly some of the local variety names in the above list refer to the same banana. It was impossible to check each definitely because of lack of fruit. The same banana names used in different localities of Java cannot always be taken as referring to one distinct variety, because the same banana variety receives different names depending on the locality from which it has been collected. The Gros Michel banana of the West Indies is called Ambon poetih in various parts of Java and Radja in Amboina and the Banda Islands. The Radja variety in Java is therefore totally different from the Radja of Ambon. The name Soesoe as used in Java may refer to two different varieties of banana. In one locality the common Apple banana of the West Indies is called Radja sereh bodas, in another locality it is called Soesoe or Soesoe bodas. The name Soesoe is also given to an entirely different banana similar to the real Soesoe in the Federated Malay States. These few cases are cited to make it clear that local names, as often given to bananas in the Dutch East Indies, may be very misleading. The names given in the list above have been taken directly from the experimental station records cited or from the local names according to the place listed. Consequently a duplication of actual varieties may exist in the list, as fruit was not always present for differentiation purposes.

A careful study made in March, 1926, for disease in the banana collection at the Ragoenan Experimental Station, situated at Pasar Minggoe, Java, showed the disease to be spread throughout the entire collection. According to the list given

above, twenty-five varieties among some one hundred fifty types were found to have the disease. During the following month a survey of the collection at the Tohoedan Experimental Station at Solo showed eight varieties affected, and at the Pasoeroean Experimental Station at Pasoeroean in eastern Java, five varieties were affected. The banana wilt is evidently widely spread throughout the Dutch East Indies, as typical cases of diseases were found on Banda Neira and Poeloe Ay of the Banda Islands in the Molucca group.

### SEVERITY OF DISEASE IN JAVA

The banana wilt in Java, as well as generally throughout the Far East, is usually not much in evidence in the small native plantings, because some five to twenty varieties of bananas are commonly planted in the same plot. Most, or a great part, of these varieties are resistant, and one occasional sick plant of a susceptible variety causes little anxiety and is often not recognized as suffering from an infectious trouble. The Ambon poetih (Gros Michel) is possibly the most susceptible of all varieties. It is seldom extensively planted by the natives as they prefer other kinds for their own use. Only when this variety is extensively planted, as is done near a special market, does the disease become really noticeable. Solid plantings of Ambon poetih on diseased soil may show severe disease within six months and may have as high as 90 per cent disease after twelve months of growth. The following diagram illustrates severe infection of Gros Michel in small, solid plantings made at the Ragoenan Agricultural Experimental Station at Pasar Minggoe, Java. The O's and and X's designate the various plants according to the planting plan. X's indicate locations of diseased plants with external symptoms.

*Banana wilt in 11.5-month-old planting at Pasar Minggoe, Java.*

**[O=healthy plant; X=diseased plant.]**

| *Variety, Ambon Poetih.* | *Variety, Sribali.* |
|---|---|
| X X O O X O O | O X X O X O X |
| X X X X X X X | O O X O X O X |
| X X X X O X X | O X X O X X |
| X O O O O X X | O X X O X O |
| **Total plants, 28.** | **Total plants, 26.** |
| **Diseased plants, 19.** | **Diseased plants, 14.** |
| **Diseased, 68 per cent.** | **Diseased, 54 per cent.** |

The variety Ambon poetih is the Gros Michel of the West Indies. Sribali was reported as being a type of Ambon poetih. The plants listed above were planted April 15, 1925. March 4, 1926, eleven and one-half months after planting, the Ambon poetih variety had 68 per cent disease (Plate 3, fig. 1; Plate 5, fig. 1) and both varieties were 100 per cent diseased. The plants were small as they were growing on rather heavy soil. The photographs clearly show the external symptoms of disease identical to that of the banana wilt in the West Indies.

Examination made in March, 1926, of other small plantings of single varieties showed severe infection in some cases. A list of these varieties with percentage of infection is given below:

*Banana wilt in plantings at Pasar Minggoe, Java.*

| | Infection. Per cent. |
|---|---|
| Radja sereh | 40 |
| Radja sereh bodas, 9 diseased among 98 plants | 9 |
| Radja sijem | 90 |
| Soesoe, 2 diseases among 64 plants (Plate 4, fig. 2) | 3 |
| Songgroito (Sri) (Plate 3, fig. 2) | 10 |

Radja sereh is similar to the Latundan of the Philippines and the Apple or Manzana variety of the West Indies. Radja sereh bodas is a type of Radja sereh. Radja sijem is similar to the Nam Wa of Siam. These two varieties are commonly found diseased wherever grown. The disease is generally associated with definite varieties grown under different conditions in various parts of the world. The Soesoe variety is the Federated Malay States type. Songgroito (Sri) is a Dutch East Indies type that is frequently subject to disease.

Isolations were made of the first cases of disease observed. The external, internal, and microscopic aspects of the cases studied were identical with the real banana wilt (Panama disease) of the West Indies. Four typical cases of disease were selected for isolations as follows:

| Variety. | Collected. | Locality. |
|---|---|---|
| Radja | Feb. 13, 1926 | Buitenzorg (Tjipakoe), Java. |
| Ambon poetih | Feb. 13, 1926 | Pasar Minggoe, Java. |
| Do. | Feb. 13, 1926 | Do. |
| Songgroito (Sri) | Feb. 13, 1926 | Do. |

In each case a pure culture of *Fusarium cubense* was isolated. No other fusaria were present in the diseased tissues. Deter-

minations of *Fusarium cubense* were made from cultural characters and spore measurements of the fungus growing upon potato agar and rice. The typical aromatic odor of the organism when grown on rice was produced.

### SPECIAL ISOLATION STUDIES

In order to prove definitely that *Fusarium cubense* is associated with all the varieties of bananas subject to the disease, sixteen varieties found diseased were collected March 25, 1926, at the Ragoenan Experimental Station, Pasar Minggoe, and taken to Buitenzorg for isolation and culture studies. The writer is indebted to Dr. Van Hall and members of the Institute voor Plantenziekten at Buitenzorg for use of laboratory and equipment. Each variety collected had typical symptoms of the disease. A list of the varieties from which isolations were made follows:

*Isolations of pure cultures of F. cubense, Pasar Minggoe banana collection, March, 1926.*

| Variety. | Place of isolation. |
|---|---|
| 1. Ambon bodas | Pseudostem. |
| 2. Besi | Do. |
| 3. Kloetoek soekoen | Do. |
| 4. Kool | Do. |
| 5. Mentek | Do. |
| 6. Radja (batoel) | Do. |
| 7. Radja koesta | Do. |
| 8. Radja pakoewon | Do. |
| 9. Radja pelilit | Do. |
| 10. Radja pelilit | Rhizome. |
| 11. Radja pretel | Pseudostem. |
| 12. Radja sereh bodas | Do. |
| 13. Radja sijem | Do. |
| 14. Sembot | Do. |
| 15. Soesoe (Banjoewangi type) | Do. |
| 16. Tjeleket | Do. |

The Besi and Sembot varieties had only mild cases of infection.

Isolations were made March 26 on acidified potato-agar plate cultures by taking small pieces of infected pseudostem and plating them out. In one case, that of Radja pelilit, isolations were made from the infected vascular bundles of the rhizome. The portion of the diseased pseudostem of variety Tjeleket was taken near the top of the plant just below the leaf blades. In all other cases portions of the pseudostem, approximately one foot above the ground, were taken. Microscopic examinations of

diseased bundles showed in all cases the presence of mycelium in the xylem tubes.

March 29 examination of the plates showed that in each case a pure culture of fusarium grew from the diseased portions. The fusaria produced from each were so striking and pure that there was no question about the presence of one single strain in all varieties. The growth from infected portions of the rhizome of the Radja pelilit was identical with that from the pseudostem.

Transfers of the fungus developed from each variety were made to tubes of potato agar, rice, and stems of *Tephrosia candida,* for final identification of the organism. Subsequent examination of these cultures proved that the organism in every case was a pure culture of *Fusarium cubense* identical in every respect, physiologically and morphologically, with the organism as described from Central America and the West Indies.(11)

The isolations made from typical cases of banana wilt (Panama disease) from this region of Java proved that *Fusarium cubense* was present in a pure state in every variety from which isolations were made. In no case was any other type of fusarium isolated. There is no reason to believe that the disease in Java is in any way different from the disease in other parts of the world.

## AUSTRALIA

Banana wilt undoubtedly has been present in Australia for many years. Tryon(13) in 1912 mentioned a disease investigated by Dr. Joseph Bancroft in 1874–1876 attacking the sugar banana in southern Queensland. The disease was also reported as occurring in the common plantain growing in that region. Tyron described the disease and stated that it was similar to the Panama disease. The description of the disease leaves no doubt that the trouble was identical with the banana wilt (Panama disease). This is especially true in view of the present findings.

The following banana varieties have been reported to be affected.

BANANA VARIETIES AFFECTED

1. Lady Finger.
2. Sugar banana.
3. Gros Michel.
4. Plantain (variety name not mentioned).

The writer made observation and isolation studies of the disease only on the Lady Finger variety. The disease was reported to me by Australian investigators as occurring on the

other named varieties. The Lady Finger banana is commonly grown in Australia. It should not be confused with the type designated as Lady Finger in the Caribbean region. The Australian Lady Finger banana is similar to the Rio banana of Tahiti and the Brazilian banana of Hawaii.

The disease was studied in a plantation at Pinkenba, down the river from Brisbane. It was severe on the Lady Finger variety and showed typical symptoms with split pseudostems and wilted, yellow leaves. Diseased specimens of the rhizome and pseudostem were taken to Brisbane for microscopic examination and isolation studies. The writer is indebted to Prof. E. J. Goddard, of Queensland University, for the use of laboratories and equipment. Internal symptoms were typical of the true banana wilt except that more yellowed strands predominated and more rotted areas were present throughout the infected pseudostem. Certain varieties of bananas affected with the fusarial wilt may show a preponderance of yellowed vascular bundles over the reddish or black. Pure cultures of *Fusarium cubense* were isolated from the rhizome and pseudostem. The fungus was isolated both from reddish black and yellow stages of discoloration in bundles.

## BURMA

The banana wilt disease was observed in southern Burma near Rangoon at the Hmawbi Agricultural Experimental Station. The disease was not seen in the northern Mandalay region or in central Burma. Only one variety of banana was found to be attacked.

### BANANA VARIETY AFFECTED

**1. Kala.**

The Kala variety is similar to the Latundan of the Philippines and the common Apple or Manzana banana of the West Indies. This variety and the Gros Michel are the two most commonly attacked in all parts of the world where grown. All characteristic symptoms including splitting were observed on diseased plants. Microscopic examination showed discolored vascular bundles with fungus mycelium in the xylem tubes. No isolations were made.

## INDIA

Basu(1) in 1912 reported the presence of a banana disease in Chinsurah. Certain varieties were said to have been killed out entirely. A description of the disease leaves no doubt that the trouble was identical with the banana wilt (Panama disease). This is especially true in view of the present findings. In 1914 Shaw(12) and in 1915 Butler(3) again reported the presence of the disease.

The present investigation covered the Dacca District, Bengal, in eastern India, and the Poona District, Bombay, in western India. In the Dacca region it was severe, especially in garden plantings that had been cultivated for years about the farm houses. The disease was observed in the Munsiganj and Rampal areas of the Dacca region. At Poona the disease was observed only on a seedling variety found growing at the Ganeshkhind Botanical Gardens.

### BANANA VARIETIES AFFECTED

1. Kabari; Dacca District, Bengal.
2. Sonkel Chanda (from seed); Poona District, Bombay.

The Kabari variety is similar to the Nam Wa of Siam and Awak of the Federated Malay States. It is commonly cultivated in the Far East. Sonkel Chanda is a seedling variety grown from the seed of the common Sonkel variety of India. Typical external symptoms of wilting and splitting were present in each case. Microscopic examination showed the presence of mycelium in the xylem tubes. Pure cultures of *Fusarium cubense* were isolated from each case of disease.

## DISCUSSION

The foregoing studies on banana wilt (Panama disease) clearly show that this disease is generally widespread in most banana sections of the world. The disease is generally associated with definite varieties wherever grown and affects these varieties most severely. Gros Michel apparently is the most susceptible. The Apple Manzana variety as known in the West Indies is generally found to be diseased to a greater or lesser degree. The Awak variety of Penang or Nam Wa of Siam is commonly diseased where grown throughout the Far East. The

following table gives the local variety names in the various countries where these diseased varieties were observed:

*Banana varieties most commonly found diseased.*

Gros Michel; West Indies and Central America. Also known as—
- Embun; Federated Malay States.
- Ambon poetih; Java.

Manzana or Apple; West Indies and Central America. Also known as—
- Latundan; Philippine Islands.
- Rastali; Federated Malay States and India.
- Kala; Burma.
- Radja sereh; Java.

Awak; Penang, Straits Settlements. Also known as—
- Nam Wa; Siam.
- Radja sijem; Java.
- Kabari; India.

*Fusarium cubense* was isolated from all typical cases of disease studied. No other fusarium was found in typical diseased lesions. Brandes(2) clearly proved that typical disease can be produced by inoculation with *Fusarium cubense*. Later studies by Carleton(4) and Reinking(9) also show this to be true. External and internal symptoms were identical in all cases of disease observed on the various varieties as grown in all countries visited. The universal presence of *Fusarium cubense* in typical cases of banana wilt throughout the areas covered in this study, considered with the successful inoculation studies previously made and the similarity of external and internal symptoms, seem to be evidence enough that the disease is everywhere identical.

## SUMMARY

Symptomatic and isolation studies clearly show that the banana wilt (Panama disease) is identical in the following countries: Philippine Islands, Straits Settlements (Singapore, Penang), Federated Malay States, Siam, Dutch East Indies, Austrialia, Burma, and India.

The banana wilt (Panama disease) is world-wide in its distribution, being found in practically all banana regions.

Certain varieties of bananas are highly susceptible to the disease wherever grown.

The Gros Michel is subject to the disease in most parts of the world where it is grown.

Studies conducted in Java show the presence of *Fusarium cubense* in all typical cases of infection. No other fusaria were found associated with typical cases of the disease.

There is no reason to believe that the disease in Java is in any way different from the disease in other parts of the world.

The universal presence of *Fusarium cubense* in typical cases of banana wilt (Panama disease) throughout the areas covered in this study, considered along with the successful inoculation studies previously made and the similarity of external and internal symptoms, seem to be evidence enough that the disease is everywhere identical.

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# ILLUSTRATIONS

PLATE 1. BANANA WILT IN THE PHILIPPINE ISLANDS AND SINGAPORE

FIG. 1. Banana wilt in Latundan variety; splitting of pseudostem. Lalakay, Los Baños, Laguna, Philippine Islands; March 31, 1925.

2. Banana wilt of Pisang embun; longitudinal section through rhizome and portion of pseudostem, showing discolored vascular bundles. Adam Road, Singapore, Straits Settlements; October 20, 1925.

PLATE 2. BANANA WILT IN SINGAPORE AND SIAM

FIG. 1. Banana wilt of Pisang embun; note drooping of outer, older leaves and upright, yellowed central leaf. Adam Road, Singapore; October 20, 1925.

2. Banana wilt of Klui Nam Wa. Bangkok Noi Experimental Orchards near Bangkok, Siam; November 8, 1925.

PLATE 3. BANANA WILT IN JAVA, DUTCH EAST INDIES

FIG. 1. Severe case of banana wilt of Pisang ambon poetih (Gros Michel). Pasar Minggoe Experimental Station, Java; March 6, 1926.

2. Banana wilt in planting of Pisang Songgroito (Sri); 10 per cent of plants diseased; apparently healthy plant of same age in background. Pasar Minggoe Experimental Station, Java; March 6, 1926.

PLATE 4. BANANA WILT IN JAVA, DUTCH EAST INDIES

FIG. 1. Banana wilt in planting of Pisang soesoe; 3 per cent of plants diseased. Pasar Minggoe Experimental Station, Java; March 6, 1926.

2. Banana wilt of Pisang radja pakoewon. Pasar Minggoe Experimental Station, Java; March 6, 1926.

PLATE 5. BANANA WILT IN JAVA, DUTCH EAST INDIES

FIG. 1. Banana wilt in planting of Pisang ambon poetih (Gros Michel); 68 per cent of plants badly diseased according to external symptoms; note stunted growth and splitting of pseudostems. Pasar Minggoe Experimental Station, Java; March 6, 1926.

2. Banana wilt in planting of Pisang sribali (Gros Michel type). Sribali is a type of Ambon poetih; 54 per cent of plants badly diseased according to external symptoms; note stunted growth. Pasar Minggoe Experimental Station, Java; March 6, 1926.

1

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PLATE 1.

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PLATE 2.

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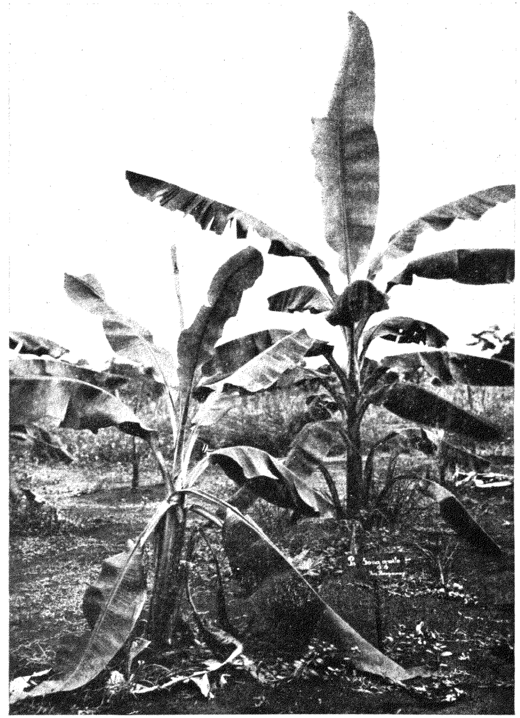

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PLATE 3.

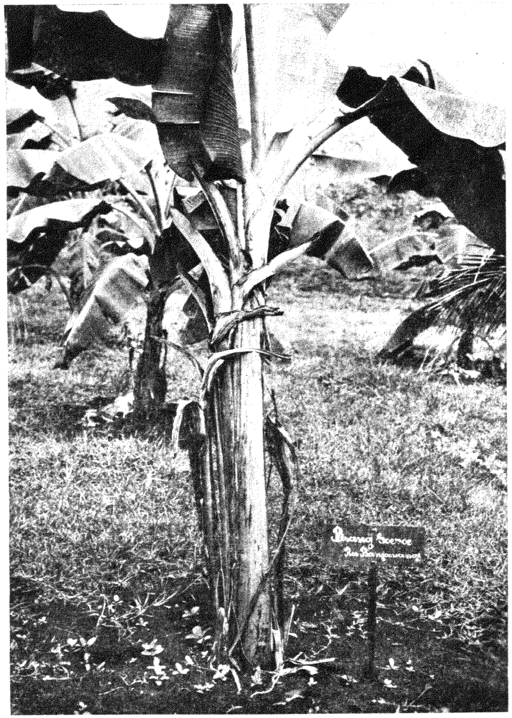
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PLATE 4.

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PLATE 5.

# CULTIVATION OF AVIAN-PEST VIRUS (NEWCASTLE DISEASE) IN TISSUE CULTURE

By TEODULO TOPACIO[1]

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The development by Burrows, Carrel, and the Lewises of various methods for cultivating different kinds of tissues in vitro was followed by the application of the technic in the propagation of several viruses affecting man and animals. Levaditi(8) kept rabies virus viable in growing cells of rabbit testicles in monkey plasma for a period of one month. In the same year Steinhardt, Israeli, and Lambert(12) cultivated the agent of vaccinia in rabbit cornea and plasma for more than thirty days. Parker and Nye(9) estimated that their cultures of this virus in rabbit testicular tissue had multiplied 51,000 times after eleven passages. Carrel and Rivers(1) also cultivated vaccinia, using chick-embryo skin, cornea, and brain, and calculated that the virus increased 10,000 to 100,000 units per cubic centimeter after eight passages. Dochez, Mills, and Kneeland(2) cultivated the virus of common cold in chick-embryo pulp for fifteen generations. Pinkerton and Haas(10) studied the virus of typhus fever in cultures of guinea-pig tissue and scrotal exudate. Foot-and-mouth disease was cultivated by Hecke(6) on the skin of guinea-pig embryos for eleven generations (forty-nine days) and in another series the virus survived for forty-six days. In both cases the virus became avirulent on further passage. In 1932 the same author(7) cultivated the virus of hog cholera.

It will be noted that the majority of the viruses thus far cultivated were diseases of man with the exception of rabies, foot-and-mouth disease, and hog cholera. More recently the virus of fowl plague was added to the list. Hallauer(5) succeeded in propagating this agent in different tissues of the chicken embryo. Single tissue or the entire embryo pulp was satisfactory for growing the virus according to this author. The following year

[1] Bureau of Animal Industry Technical Bulletin 5. From the veterinary research division, Bureau of Animal Industry, Manila. Received for publication January 12, 1933.

Plotz(11) at the Pasteur Institute also succeeded in cultivating fowl plague in fifteen passages on chicken-embryo pulp covering a period of ninety-four days.

Concerning Newcastle disease or avian-pest virus the writer failed to find any report in literature dealing with its cultivation in vitro. In the present paper the successful cultivation of this agent will be described.

## MATERIALS

In this work three strains of virus have been used; namely, laboratory strain, Farinas strain, and Stotsenburg strain. Best results were obtained with the laboratory strain which was kept in continuous passage for about five years.

*Preparation of the virus.*—The spleen of a bird artificially infected was removed aseptically at the height of the disease (four or six days after inoculation). It was ground in a sterile mortar and then suspended in 4 cc of Tyrode solution pH 8.4. The mixture was allowed to extract for one or two hours in a Frigidaire and then centrifuged at low speed for one minute to cause the tissue fragments to settle. The supernatant material served as stock virus for the initial culture. The subculture virus was prepared from one or more Carrel flask cultures suspended in 1 to 2 cc of Tyrode solution as described for the initial virus material.

*Plasma.*—Plasma of heparinized blood from healthy susceptible birds was collected aseptically. A 1 : 1000 heparin-saline solution was added to the heart blood in the proportion of 1 cc of heparin to 10 cc of blood to prevent coagulation. After centrifugation the clear plasma was stored on crushed ice in the refrigerator until wanted for use.

*Embryo tissue.*—Chick embryos 8 to 10 days old were utilized in the preparation of the tissue medium. Each embryo was minced fine with scissors in a Petri dish, and the fragments were washed in Tyrode solution before exposure to the virus suspension.

*Test birds.*—White Leghorns of known susceptibility were employed as virus producers and test birds.

*Tyrode solution.*—The following formula was adopted: NaCl, 8 g; KCl, 0.2 g; $CaCl_2$, 0.2 g; $MgCl_2$, 0.1 g; $NaHPO_4$, 0.05 g; $NaHCO_3$, 1 g; glucose, 1 g; distilled water, 1,000 cc. After filtration through a Seitz filter the solution was tested for sterility before use.

## TECHNIC

Plasma diluted with Tyrode solution in the proportion of 1 part plasma and 1 to 2 parts Tyrode was distributed in sterile Carrel D-flasks in 2.5-cc amounts. One cubic centimeter of virus suspension was added to each minced whole embryo tissue and the mixture was stirred thoroughly and allowed to stand for one-half hour. With a broad-tip pipette, the tissue-virus mixture was distributed in each Carrel D-flask in 0.5-cc amounts.[2] The flasks were then shaken gently from side to side to disperse the tissue particles equally in the medium, which became firm in a few minutes. Cotton plugs and rubber caps were used as stoppers. The cultures were incubated at 37° C., and transfers were made every three or five days. The final dilution of the virus in initial cultures was approximately 1 : 30.

## ADAPTABILITY OF THREE STRAINS OF VIRUS TO CULTIVATION

To determine which strain was most suitable for cultivation, initial cultures of each strain were made and tested separately.

*Laboratory strain.*—Of the initial cultures made with this strain the average survival period was six to fourteen days. A test bird injected with the 14-day-old culture developed typical symptoms without profuse diarrhœa, but complete recovery followed. One culture 6 days old when injected into a susceptible bird killed the fowl. Another 6-day-old culture produced marked symptoms in another bird but it recovered. The birds that recovered were later found immune against a test dose of a 1: 10 dilution of virulent saliva injected in the breast muscle.

*Farinas strain.*—Four-day-old initial cultures of this strain produced mild but atypical symptoms of avian pest in the inoculated birds, which later resisted a test inoculation of virulent saliva.

*Stotsenburg strain.*—Six-day-old initial cultures of this strain when injected into susceptible birds failed to infect. The birds succumbed to regular test dose of 1 cc of a 1: 10 dilution of virulent saliva.

In the viability test of the cultures, the entire contents of one or two Carrel flasks were emulsified in a little Tyrode solution and injected in the breast muscle of the test bird. The birds that survived were injected with a virulent test dose of infected saliva fourteen days after apparent recovery.

[2] Five-tenths cc tissue-virus mixture contains 0.1 cc virus suspension and 0.4 cc tissue.

CULTIVATION OF THE LABORATORY STRAIN IN TISSUE CULTURE

The result of the adaptability tests just described gave evidence that the laboratory strain was the most suitable for cultivation. The first initial culture was prepared February 15, 1933, according to the technic already outlined. Up to and including the thirty-first subculture, June 9, 1933, the virus remained infective, representing a total viability period of one hundred twelve days.

Every viable subculture in the entire series of thirty-one subplants was diluted from 1 to 30 times, approximately. There was, therefore, no doubt that the virus had multiplied regularly in the medium employed in thirty-one successive subplants. Farinas(3) determined the minimal infective dose of virulent saliva as 1 cc of a dilution of 1 : 1,250. In my own tests I succeeded in infecting a bird with 1 cc of a dilution of 1 : 25,000 virulent blood from a natural case. The thirty-first subplant killed a test bird within the regular period of five days after the inoculation of the standard test dose used in the beginning of the series. This is clear evidence that multiplication of the virus had taken place.

The intervals between testing periods for viability of subplants varied from every subplant in the first ten transfers to every five or more subplants thereafter in order to reduce the waste in the use of birds to the minimum. In all seventeen test birds were used, of which thirteen died and four developed symptoms but recovered. Those that recovered were found immune to a test dose of 1 cc of a 1 : 10 dilution of virulent saliva from infected birds. Five cubic centimeters of culture virus in saline comprised the dose given intramuscularly through the viability tests of the subcultures.

In some instances the cultures became contaminated, but by filtering a Tyrode suspension of these through a Seitz filter or Berkefeld N or W candles, the virus was freed from contamination without difficulty and no interruption occurred throughout the entire series up to and including the thirty-first subculture. This filterability of the culture virus through such filters of dense porosity seems to indicate that the virus particles have approximately the same size as the particles of foot-and-mouth disease virus or possibly are smaller. At any rate a certain amount of contamination did not seem to interfere with the viability and multiplication of the active agent. The filtrates containing the virus were used to inoculate the subcultures

immediately following the contaminated ones and the chain was kept intact until further transfers were discontinued. Table 1 records the thirty-one subplants in the entire series including the viability tests.

TABLE 1.—*Viability tests on avian-pest virus (laboratory strain) cultivated in normal chicken plasma and embryo pulp at 37° C.*

| Date. | Bird No. | Initial culture. | Subplant. | Age of virus when tested. | Amount injected. | Result. |
|---|---|---|---|---|---|---|
| | | | | *Days.* | *cc.* | |
| Feb. 15 | 1 | No. 1 | | 7 | 5 | Died. |
| Feb. 18 | | | First | 7 | | |
| Feb. 21 | 2 | | Second | 11 | 5 | Do. |
| Feb. 25 | 3 | | Third | 14 | 5 | Do. |
| Feb. 28 | 4 | | Fourth | 17 | 5 | Do. |
| Mar. 3 | 5 | | Fifth | 22 | 5 | Slight symptoms; recovered.[c] |
| Mar. 7 | 6 | | Sixth | 27 | 5 | Died. |
| Mar. 11 | 7 | | Seventh | 29 | 5 | Do. |
| Mar. 16 | 8 | | Eighth | 33 | 5 | Do. |
| Mar. 20 | 9 | | Ninth [a] | 37 | [b] 10 | Do. |
| Mar. 23 | 10 | | Tenth | 40 | 5 | Do. |
| Mar. 26 | 11 | | Eleventh | 43 | 5 | Clinical symptoms; recovered.[c] |
| Apr. 7 | 12 | | Fifteenth | 54 | 5 | Very ill; killed. |
| Apr. 25 | 13 | | Twentieth | 72 | 5 | Slight symptoms; recovered.[c] |
| May 2 | 14 | | Twenty-second. | 77 | 5 | Died. |
| May 14 | 15 | | Twenty-fifth. | 90 | 5 | Do. |
| June 5 | 16 | | Thirtieth [a] | 107 | 5 | Slight symptoms; recovered.[c] |
| June 9 | 17 | | Thirty-first | 112 | 5 | Died. |

[a] Cultures became contaminated but after filtration contamination was removed and subplants were resumed.
[b] Filtrate.
[c] Immune to test inoculation with virulent saliva.

## TISSUE PREDILECTION

Tissue predilection of the virus under cultivation was not observed during the work since the virus when grown in separate cultures of skin, visceral organs, and brain, showed no apparent peculiar behavior. Such cultures were as viable as those grown in a medium of whole embryo pulp.

One interesting observation with regard to the filtered virus was the fact that whenever it was used as inoculum the initial culture had a noticeably lower virus content, as shown by the mild symptoms produced and the prompt recovery of injected

susceptible birds. On subsequent subcultures, however, the same dose of culture injected into a susceptible fowl was invariably fatal. Evidently the original concentration of the virus was regained by multiplication after a number of passages, since in every transfer the virus had suffered increasing dilutions at the rate already stated.

### IMMUNITY IN CULTURE VIRUS

There is reason to suspect that a subinfectious dose of culture virus might produce immunity without eliciting marked symptoms in the inoculated bird. Test birds inoculated with culture virus from the 5th, 11th, 13th, and 16th subplants, for example, showed slight evidence of infection followed by recovery, yet they resisted a retest with virulent saliva fourteen days afterwards. The birds were immune. In order to establish this phase of immunity on a permanent basis, further work would be necessary. It appears, therefore, that the immunity induced by cultured virus did not differ from that which followed an attack of natural infection.

### CULTURED VIRUS VACCINE

Preliminary work on this subject has been started. While the result in a few trials appeared promising, further experiments on this point are in progress in order that a definite conclusion can be drawn.

### HISTOPATHOLOGICAL OBSERVATIONS ON SLIDE CULTURES

Fragments of spleen, liver, and brain from infected birds were grown in hanging drops of normal chicken plasma at 37° C. In the same manner normal embryo organs (skin, liver, intestines, etc.) infected in vitro were cultured in plasma drops. In a number of trials the growing tissues five days old were examined microscopically under high and low magnifications, but no abnormal intracellular changes of great significance were noted. In preparations fixed in Schaudinn's solution and stained with eosin hæmatoxylin, the nuclei of the epithelial cells appeared pyknotic. Similar intranuclear changes were observed by Fukushima, Shimomura, and Oyama (4) in the cells of sections from visceral parenchymatous organs removed from birds that had died of the disease. Of course, it is quite possible that we have not yet hit upon the staining method that would bring into view the changes that the ordinary technic failed to demonstrate. Likewise, these authors failed to note any cellular inclusions in the course of their studies.

## DISCUSSION

During the selection of a suitable strain of virus for purposes of cultivation it was shown that a certain strain was more adaptable than others. In the present work the laboratory strain proved to be the most satisfactory, probably because it had been regularly passed through fowls for several years, acquiring in this wise a more uniform biological behavior with respect to infectivity, resistance to environment, response to available food material, tenure of survival, and apparent readiness to multiplication.

The fact that this strain was carried through thirty-one generations for one hundred twelve days with little or no deterioration in its virulence for susceptible birds proves that the virus lived and multiplied in the medium employed. Such survival and propagation of the virus were further proved by the fact that each transfer or subplant suffered a dilution of 1 to 30, approximately. The rate of multiplication might be expressed by the figures $(1:30)^{31}$ Results obtained from the use of single tissue or whole-embryo pulp as medium did not show evidence of tissue predilection insofar as survival and multiplication of the virus were concerned. Simple and compound tissue media were equally satisfactory for propagation.

That the immunity induced by the culture virus did not differ from that which followed the inoculation of natural virus, was shown by the birds that recovered from the culture virus and later resisted a test inoculation of virulent saliva. Moreover, vaccines prepared from culture virus induced an active immunity in susceptible birds which later withstood fatal doses of natural virus. Although this was tried on a few birds only, culture virus gives promise in the preparation of a potent vaccine.

Slide cultures of embryonic and adult tissues failed to reveal intracellular changes of great significance aside from nuclear pyknosis of the skin epithelium. This failure, however, might be due to the fact that a suitable staining method has not yet been devised. Improved tinctorial technic may disclose such changes.

## CONCLUSIONS

1. Avian-pest virus was cultivated in a medium consisting of chick-embryo tissue and plasma for thirty-one generations over a period of one hundred twelve days. In such medium the rate of multiplication was expressed by the figures $(1:30)^{31}$.

2. Culture virus did not seem to differ from natural virus in its ability to induce active immunity as shown by the susceptible birds immunized with the former and which resisted the injection of the latter.

3. A vaccine prepared from culture virus gave promise for the development of an active immunizing agent.

4. Culture virus tolerates a considerable amount of contamination, which denotes a high degree of resistance to bacterial encroachment.

5. Beyond a nuclear pyknosis of the epithelial cells, no intracellular change of great significance was noted in growing tissue cells in the presence of active virus.

ACKNOWLEDGMENT

Thanks are due Dr. E. C. Farinas for supplying a virus strain; Major Raymond Randall, United States Army Medical Department Research Board, for the Stotsenberg virus; and Dr. A. B. Coronel for technical assistance in this work.

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# THE NATURAL ENEMIES OF ALEYRODIDÆ IN TROPICAL ASIA [1]

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During the course of the investigations upon the natural enemies of the citrus blackfly (*Aleurocanthus woglumi* Ashby) in tropical Asia from 1929 to 1931, inclusive, observations were also made upon the species attacking other members of the family Aleyrodidæ. These observations were most extensive in Malaya, Java, and Sumatra, but advantage was taken of limited opportunities for study in the Philippine Islands, Siam, Burma, and Ceylon. A number of the host species noted in tropical Asia are of economic importance, and two of them, *Aleurocanthus woglumi* in Cuba and tropical America (1) and *A. spiniferus* Quaintance in Japan, (3) have been effectively controlled by parasite introductions. Other species are major pests also, and a record of their natural enemies is of value in case projects on their biological control are contemplated.

In 1927 F. Silvestri (5) published an account of the Aleyrodidæ infesting citrus trees in the Far East, giving extensive records of the natural enemies attacking them. The majority of species collected were described by him as new. The present paper deals largely with the host relationships and distribution of the parasite species listed by Silvestri which are found in the tropical part of Asia, and, in addition, records a number of other parasites and predators on this group of insects.

The list of host species is given below, and under each are given the various natural enemies which have been found to

[1] The identifications of the insects listed herein have been made by the Division of Identification and Classification of Insects of the United States Bureau of Entomology, the Coleoptera being determined by E. A. Chapin, the Lepidoptera by Carl Heinrich, the Diptera by J. M. Aldrich, the Hymenoptera by A. B. Gahan, and the Aleyrodidæ by P. W. Mason and also by A. C. Baker of the Division of Fruit and Shade Tree Insects.

attack it. The starred species have been collected by the author; the remainder are based upon published records.

## NATURAL ENEMIES OF ALEYRODIDÆ

**ALEUROCANTHUS CITRIPERDUS** Quaintance and Baker.

Upon citrus in southern China, Malaya, the Dutch East Indies, and Ceylon.

Parasites:

* *Amitus hesperidum* Silvestri; Platygasteridæ.
* *Amitus hesperidum* subsp. *variipes* Silvestri; Platygasteridæ.
* *Encarsia merceti* Silvestri; Eulophidæ.
* *Eretmocerus serius* Silvestri; Eulophidæ.
* *Prospaltella divergens* Silvestri; Eulophidæ.
* *Prospaltella smithi* Silvestri; Eulophidæ.
* *Prospaltella* sp.; Eulophidæ.

Predators:

* *Acletoxenus indica* Malloch; Drosophilidæ.
* *Acletoxenus* sp. nov.; Drosophilidæ.
* *Chrysopa* sp.; Chrysopidæ.
* *Cryptoblabes gnidiella* Millière; Pyralidæ.
* *Cybocephalus* sp.; Nitidulidæ.
* *Scymnus smithianus* Silvestri; Coccinellidæ.
* *Scymnus* sp.; Coccinellidæ
* *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

**ALEUROCANTHUS INCERATUS** Silvestri.

On citrus in Indo-China.

Parasites:

*Prospaltella clypealis* Silvestri; Eulophidæ.
*Prospaltella opulenta* Silvestri; Eulophidæ.

Predator:

*Scymnus* sp.; Coccinellidæ.

**ALEUROCANTHUS LONGISPINUS** Quaintance and Baker.

Upon bamboo in Malaya.

Parasites:

* *Eretmocerus serius* Silvestri; Eulophidæ.
* *Prospaltella divergens* Silvestri; Eulophidæ.

**ALEUROCANTHUS SPINIFERUS** Quaintance.

Upon citrus and ornamental trees throughout subtropical and tropical Asia.

Parasites:

*Amitus hesperidum* subsp. *variipes* Silvestri; Platygasteridæ.
*Amitus* sp.; Platygasteridæ.
* *Encarsia merceti* Silvestri; Eulophidæ.
* *Eretmocerus serius* Silvestri; Eulophidæ.
* *Prospaltella divergens* Silvestri; Eulophidæ.
*Prospaltella ishii* Silvestri; Eulophidæ.
* *Prospaltella smithi* Silvestri; Eulophidæ.
* *Prospaltella* sp.; Eulophidæ.

Predators:

* *Acletoxenus indica* Malloch; Drosophilidæ.
* *Acletoxenus* n. sp. nov.; Drosophilidæ.
*Chrysopa fulvolineata;* Chrysopidæ.
* *Chrysopa* sp.; Chrysopidæ.
* *Cryptognatha* sp. nov.; Coccinellidæ.
*Delphastus* sp.; Coccinellidæ.
* *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

**ALEUROCANTHUS SPINOSUS (Kuwana).**

Upon *Anona* sp. and *Hibiscus* sp. at Manila, Philippine Islands.

Parasites:

* *Prospaltella clypealis* Silvestri; Eulophidæ.
* *Prospaltella* sp. nov.; Eulophidæ.

Predator:

* *Scymnus* sp.; Coccinellidæ.

**ALEUROCANTHUS WOGLUMI Ashby.**

Upon citrus and occasional other trees throughout subtropical and tropical Asia.

Parasites:

* *Encarsia merceti* Silvestri; Eulophidæ.
* *Eretmocerus serius* Silvestri; Eulophidæ.
* *Prospaltella divergens* Silvestri; Eulophidæ.
* *Prospaltella smithi* Silvestri; Eulophidæ.
* *Prospaltella* sp.; Eulophidæ.

Predators:

* *Acletoxenus indica* Malloch; Drosophilidæ.
* *Acletoxenus* sp. nov.; Drosophilidæ.
* *Chrysopa* sp.; Chrysopidæ.
* *Cryptoblabes gnidiella* Millière; Pyralidæ.
* *Cryptognatha* sp. nov.; Coccinellidæ.
* *Scymnus smithianus* Silvestri; Coccinellidæ.
* *Scymnus* sp.; Coccinellidæ.
* *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.
* *Cybocephalus* sp.; Nitidulidæ.

**ALEUROCANTHUS sp.**

On *Anona* sp. at Singapore, Straits Settlements.

Parasites:

* *Prospaltella clypealis* Silvestri; Eulophidæ.
* *Prospaltella* sp. nov.; Eulophidæ.

Predator:

* *Scymnus* sp.; Coccinellidæ.

**ALEUROCANTHUS sp.**

Upon citrus at Medan, Sumatra.

Parasites:

* *Eretmocerus serius* Silvestri; Eulophidæ.
* *Prospaltella divergens* Silvestri; Eulophidæ.
* *Prospaltella* sp. nov.; Eulophidæ.

Predator:

* *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

**ALEUROCYBOTUS SETIGERUS Quaintance and Baker.**

On *Pandanus* at Manila, Philippine Islands.
Parasite:
*Encarsia persequens* Silvestri; Eulophidæ.

**ALEUROLOBUS SUBROTUNDUS Silvestri.**

Upon citrus in Indo-China.
Parasite:
*Prospaltella armata* Silvestri; Eulophidæ.

**ALEUROPLATUS sp.**

Upon *Ficus religiosa* Linnæus at Singapore, Straits Settlements.
Parasites:
* *Eretmocerus* sp. nov.; Eulophidæ.
* *Prospaltella strenua* Silvestri; Eulophidæ.
Predator:
* *Scymnus* sp.; Coccinellidæ.

**ALEYRODES RICINI Misra.**

On castor in India.
Parasites:
*Aphelinus fuscipennis* Howard; Eulophidæ.
*Prospaltella lahorensis* Howard; Eulophidæ.
*Prospaltella* sp.; Eulophidæ.
Predator:
*Chrysopa* sp.; Chrysopidæ.

**ALEYRODES sp.**

Upon *Sauropus androgynus* Merrill at Singapore, Straits Settlements.
Parasite:
* *Eretmocerus* sp. nov.; Eulophidæ.
Predators:
* *Scymnus* sp.; Coccinellidæ.
* *Scymnus* sp.; near *pallidicollis* Mulsant; Coccinellidæ.

**ASTEROCHITON sp.**

Upon citrus in Java and at Singapore, Straits Settlements.
Parasite:
* *Prospaltella strenua* Silvestri; Eulophidæ.

**BEMISIA GIFFARDI Kotinsky.**

Upon citrus in Malaya, Java, and Sumatra.
Parasite:
* *Prospaltella strenua* Silvestri; Eulophidæ.

**DIALEURODES CITRI (Ashmead).**

On citrus and ornamentals in Japan, China, and India.
Parasites:
*Prospaltella citrofila* Silvestri; Eulophidæ.
*Prospaltella lahorensis* Howard; Eulophidæ.
Predators:
*Brumus suturalis* Fabricius; Coccinelidæ.
*Cryptognatha flavescens* Motsch.; Coccinellidæ.
*Serangium* sp.; Coccinellidæ.

**DIALEURODES CITRIFOLII (Morgan).**

On citrus in Indo-China.

Parasites:

*Prospaltella perstrenua* Silvestri; Eulophidæ.
*Prospaltella strenua* Silvestri; Eulophidæ.

**DIALEURODES EUGENIAE Maskell.**

Upon *Eugenia* spp. in Java and Sumatra.

Parasite:

* *Prospaltella strenua* Silvestri; Eulophidæ.

**NEOMASKELLIA BERGII (Signoret).**

Upon sugar cane at Singapore, Straits Settlements.

Parasites:

* Platygasteridæ (an undetermined species).
*Prospaltella tristis* Zehntner; Eulophidæ.

Predator:

*Scymnus* sp.; Coccinellidæ.

## THE HOST SPECIES

The Aleyrodidæ of tropical Asia are exceptionally abundant in the number of species that occur upon native shrubs and trees. With the great majority of species the numerical level is quite low, although with a smaller number, particularly of the genus *Aleurocanthus,* the status of a major pest is occasionally attained. This genus is perhaps the dominant one of the family in tropical Asia, and *A. spiniferus, A. citriperdus,* and *Aleurocanthus* sp., at times heavily infest citrus trees in that region. This applies to a lesser extent to *A. woglumi* also. *Aleurocanthus spinosus* is often very abundant on *Anona* and *Hibiscus* in the Philippine Islands.

The seasonal abundance of the above species is quite largely determined by climatic conditions. *Aleurocanthus woglumi* suffers a high mortality during periods of relatively low humidity and scant rainfall, whereas *A. citriperdus* flourishes during these periods and is then greatly reduced by fungus attack during the rainy season. This reaction to climatic conditions has a close relationship to the effectiveness of parasite attack. Those host species which attain maximum abundance during the rainy season are in general more effectively attacked by the various natural enemies. In the case of *A. woglumi* the optimum conditions for the host and the parasites are the same, and maximum effectiveness of the latter is secured. In Malaya and the Dutch East Indies an exceptionally large number of parasite species are found to attack practically every species of the genus. Five parasites and nine predators were found attacking *A. wog-*

*lumi* in that region. A similar condition exists with respect to the other species that occur there.

The genus *Aleyrodes* is not at all common in tropical Asia, at least in so far as the occurrence of appreciable infestations is concerned; and only a single species, as yet undetermined, was found in sufficient numbers to permit of collection in quantity for parasite rearings. This species occurs upon *Sauropus androgynus* Merrill at Singapore. Occasional plants are heavily infested, but the colonies seen were soon greatly reduced by attack of the various natural enemies.

Misra(4) records *Aleyrodes ricini* as a pest of castor (*Ricinus communis* L.) in India. It is of general distribution throughout the country and at times becomes a serious pest.

Several species of *Dialeurodes* were noted upon citrus and other plants in the Malayan region, though usually in limited numbers. The commonest was an undetermined and possibly new species upon pummelo at Medan, Sumatra. Conspicuous by its absence was *D. citri,* which has nearly world-wide distribution. Only one species of this genus showed any evidence of parasitization, this being *D. eugeniæ* upon *Eugenia* sp. in Java and Sumatra. Both sides of the leaves were heavily infested, the lower more heavily than the upper, and a considerable number of the pupal cases showed parasite emergence holes. The one species of which specimens were secured was *Prospaltella strenua.*

*Dialeurodes citri* is occasionally found quite abundant upon citrus hedges and orchard trees in India, though only under well-shaded conditions. It has also been recorded as occurring upon several ornamental plants. Woglum(6) gives an account of the habits of this species in India, and of the search made for its natural enemies in the Far East. It occurs generally throughout India, though never as a commercial pest, and is also recorded from China and Japan.

The general ineffectiveness of natural control of the species of this genus is in marked contrast to that shown in the case of the species of *Aleurocanthus.*

The single species of *Aleuroplatus* observed was present in great abundance upon the foliage of *Ficus religiosa* at Singapore. Natural enemies were present in considerable numbers, but they were not appreciably effective, as a population approaching the maximum persisted upon the foliage.

An undetermined species of *Asterochiton* was noted upon citrus throughout Java and at Singapore. The infestation was

relatively light and confined almost entirely to the young foliage of water sprouts growing from the base or the lower part of the trunk of the tree. A large percentage of individuals showed parasite attack; in fact, in eastern Java it was difficult to find unparasitized pupæ. Natural control was apparently consistently effective.

*Bemisia giffardi* was noted in small numbers upon citrus in Malaya and in Java and Sumatra. Occasional individuals of a single parasite species, *Prospaltella strenua*, were reared from the pupæ, but the numbers of the host secured were too small to give an indication of the extent to which the parasite was responsible for this numerical scarcity.

A pest of sugar cane, *Neomaskellia bergii*, which is of some economic importance in certain sections of tropical Asia, was noted in small numbers at Singapore. A large percentage of the pupal cases showed multiple parasite-emergence holes. Natural control appeared to be fully effective throughout the season. No adult parasites were secured from the material collected, and a determination is therefore not possible. Dammerman (2) records *Prospaltella tristis* as often heavily parasitizing this host in Java.

## THE PARASITES

In number of species and in general effectiveness the genus *Prospaltella* is dominant among the parasites of Aleyrodidæ in tropical Asia. The genus is particularly well represented among the parasites of *Aleurocanthus*, and every species of that genus encountered showed attack by one or more species of *Prospaltella*. *Prospaltella divergens* is the most prominent member of the genus in Malaya and the Dutch East Indies and is largely responsible for the natural control of *Aleurocanthus woglumi* in that section. Occasionally it may be superseded by *Eretmocerus serius*. The distribution of *P. divergens* is apparently limited to Malaya and the Dutch East Indies. This species normally reproduces parthenogenetically, a habit not general in the genus. An unsuccessful effort was made to establish this parasite upon *A. woglumi* in Cuba.

In addition to the above host *P. divergens* was also found abundant upon *A. citriperdus*, *A. longispinus*, *A. spiniferus*, and *Aleurocanthus* sp.

*Prospaltella lahorensis* is recorded by Woglum (6) as a parasite of *Dialeurodes citri* in India, and an attempt was made to

effect its introduction into the United States for the control of that pest. It has since been recorded by Misra(4) as attacking *Aleyrodes ricini.*

*Prospaltella citrofila* is recorded by Silvestri(5) as a parasite of *Dialeurodes citri* in Indo-China, while *P. perstrenua* upon *Dialeurodes citrifolii* and *P. armata* upon *Aleurolobus subrotundus* are found in the same country.

*Prospaltella smithi* was found as a parasite of *Aleurocanthus citriperdus, A. spiniferus,* and *A. woglumi* in Malaya, the Dutch East Indies, and Ceylon. It is recorded by Silvestri from southern China. This species was introduced into Japan in 1925 and is reported to have effectively controlled a heavy infestation of *A. spiniferus* in that country. Under normal conditions in Malaya, *P. smithi* is the third most abundant of the parasites of *A. woglumi,* and only occasionally does it assume a dominant status.

In the Philippine Islands *Aleurocanthus spinosus* is rather heavily parasitized by *Prospaltella clypealis,* and the same parasite was reared from *Aleurocanthus* sp. on *Anona* at Singapore. Silvestri originally described the species from Indo-China as a parasite of *Aleurocanthus inceratus* Silvestri on citrus.

*Prospaltella strenua* was found to occur in Malaya and the Dutch East Indies upon *Aleuroplatus* sp., *Asterochiton* sp., *Dialeurodes eugeniae,* and *Bemisia giffardi.* The material upon which the species was described by Silvestri was reared from *Bemisia giffardi* collected at Macao in southern China. It is also recorded from *Dialeurodes citrifolii* in Indo-China. In Malaya and Java this parasite is particularly abundant and effective against *Asterochiton* sp. on citrus and *Dialeurodes eugeniae* on *Eugenia* spp. It was difficult to find unparasitized pupæ of the former host. In view of the range of host genera covered by this parasite, it would appear probable that it would be a useful enemy of *Dialeurodes citri,* which is an important pest of citrus in Florida and elsewhere. This host, however, is not known to occur in the Malayan region, consequently no observations could be made upon it. Silvestri does not record *P. strenua* upon this host in southern China.

Several additional species of *Prospaltella,* as yet undetermined or undescribed, have been reared from *Aleurocanthus spinosus* in the Philippine Islands; *A. citriperdus, A. spiniferus,* and *A. woglumi* at Medan, Sumatra; *A. woglumi* at Colombo, Ceylon; *Aleyrodes ricini* in India, and one or two others from *Aleurocanthus* spp. at Singapore and at Medan, Sumatra.

*Encarsia merceti* is common, though not abundant, as a parasite of *A. woglumi* in Malaya and the Dutch East Indies. It was also reared from *A. citriperdus* and *A. spiniferus* in the same region, and was originally described from *A. woglumi* collected at Singapore. *Encarsia persequens* is recorded by Silvestri as a parasite of *Aleurocybotus setigerus* at Manila, Philippine Islands.

*Eretmocerus serius* ranks next in importance to *P. divergens* as a parasite of *Aleurocanthus* in Malaya and the Dutch East Indies. It has been collected also in Siam, Burma, and Ceylon upon *A. woglumi,* and has also been reared from *A. citriperdus, A. spiniferus, A. longispinus,* and *Aleurocanthus* sp., the latter host being only upon citrus at Medan, Sumatra. An extended account of the biology of this species has been presented in an earlier publication.(1) All aleyrodid parasites previously studied have proved to be of true internal habit, but this species departs from that custom by depositing its eggs upon the leaf surface beneath the host larva, the parasite larva then feeding externally during its first two instars, after which it enters the host's body immediately after the latter has transformed to the pupal stage. Two generations are produced upon each generation of the host. The parasite was introduced into Cuba and various other countries in tropical America in 1930 and succeeding years, and has been completely successful in the control of *Aleurocanthus woglumi.*

An undescribed species of *Eretmocerus* occurs abundantly as a parasite of *Aleuroplatus* sp. on *Ficus religiosa* at Singapore, though not sufficiently effective to control the host. Another new species occurs upon *Aleurodes* sp. infesting *Sauropus androgynus* at Singapore. Shortly after the first observations upon it the entire infestation very largely disappeared, the parasite probably being the dominant factor in its reduction.

The genus *Eretmocerus* includes an exceptional number of species which are capable of effectively controlling their hosts. *Eretmocerus haldemani* Howard is credited with effectively controlling the woolly white fly (*Aleurothrixus howardi* Quaintance) in Florida and Cuba. In all the species observed there has been shown an exceptional adaptation to environmental conditions. The females are unusually active in the search for hosts, and this results in a high rate of parasitization even where the host is scarce. This, in conjunction with the development of two generations to each generation of the host, insures a sufficiently high population at all times to check rapidly any incipient outbreak.

The platygasterid *Amitus hesperidum* was reared in considerable numbers from *Aleurocanthus citriperdus* in eastern Java, the extent of parasitization in some infestations approaching 50 per cent. Silvestri records it upon the above host at Hongkong and at Singapore.

The subspecies *A. hesperidum variipes,* described by Silvestri from *Aleurocanthus spiniferus* collected at Sanshaci, Changsha, China, was found to be very abundant in Sumatra upon *A. citriperdus* at Brastagi (elevation 4,500 feet), but was not seen in the infestations near sea level. Although the percentage of parasitization as revealed by an examination of the pupal cases was rather high, yet the host population at the time of examination was very nearly the maximum possible. Six months later, however, the trees were practically free from infestation. At the time of the first examination the adult parasites were present in abundance upon the foliage, and the host species was very largely in the egg stage, with extensive hatching taking place. The parasite females were very actively engaged in ovipositing in these newly hatched larvæ, preferably those which had not yet settled and were still lacking the black pigmentation, though larvæ which had already begun feeding were also attacked. In contrast to this, Silvestri records females of *A. hesperidum* as apparently ovipositing in the host pupæ.

*Amitus* sp. is recorded as parasitic upon *Aleurocanthus spiniferus* in southern Japan.

## HYPERPARASITES

In all of the rearings of aleyrodid parasites made in the course of these investigations the hyperparasites recorded were all restricted to the single genus *Ablerus.* All species of *Aleurocanthus* collected in Siam, Malaya, and the Dutch East Indies yielded large numbers of *Ablerus machrochaeta* subsp. *inquirenda* Silvestri, which evidently attacks indiscriminately all of the primary parasites of the genus *Aleurocanthus.* The mortality effected among these parasites was estimated at approximately 50 per cent. Occasional individuals were reared from *Amitus hesperidum* parasitic upon *Aleurocanthus citriperdus* in eastern Java, and from the variety *variipes* on the same host at Brastagi, Sumatra. This hyperparasite apparently is restricted to the parasites of *Aleurocanthus. Ablerus machrochaeta* Silvestri was described from material reared from *Aleurocanthus inceratus* in Indo-China and was presumed to be parasitic upon *Prospaltella opulenta.* It is also recorded from southern China upon

*A. spiniferus. Ablerus connectans* Silvestri was found to be as abundant in Ceylon as is the first-named species in the Malayan region. Dammerman (2) lists *A. pulchriceps* Zehntner as a parasite of *Aleurolobus longicornis* Zehntner in Java, but it more probably develops upon other parasites of this host.

### THE PREDATORS

Several coccinellids are found from time to time attacking the various species of Aleyrodidæ, but it is very seldom that they exert an influence comparable to that of the internal parasites. The commonest of these species is *Scymnus* sp., near *pallidicollis*, which occurs in practically every infestation, though usually in small numbers. Its preferred host is *Aleurocanthus citriperdus*, and only a very few were found attacking *A. woglumi*. It occurs also in infestations of other genera of Aleyrodidæ. The adult beetles feed largely upon the early larval instars, while the larvæ feed upon all the larval instars and upon the pupæ also. The mature larvæ carry upon the body a dorsal shield built up of the cast skins of the host which have become entangled in the long body hairs.

Several undetermined species of *Scymnus* occur generally throughout tropical Asia as occasional predators upon Aleyrodidæ and upon several diaspine Coccidæ also. They were noted to attack *Aleurocanthus, Aleuroplatus,* and *Aleyrodes.*

*Scymnus smithianus,* predacious upon *Aleurocanthus citriperdus* and *A. woglumi,* was found only in the single locality of Kaban Djahné, Sumatra (elevation 4,200 feet). The larvæ are distinguishable from others attacking Aleyrodidæ by the black transverse segmental bands on the dorsum. Both larvæ and pupæ of *S. smithianus* are heavily attacked by *Aminellus* sp. nov. near *niger* Masi. This coccinellid was introduced into Cuba in 1930 for colonization upon *A. woglumi,* and apparently became established, though only small numbers could be found in the field.

Small colonies of *Cryptognatha* sp. nov.[2] were found in isolated localities in the Malayan region, one feeding upon *A. woglumi* at Kuala Lumpur, Federated Malay States, and another upon *A. spiniferus* at Medan, Sumatra. The adult beetles and larvæ may feed exclusively upon the eggs where the host is

[2] With reference to this group Dr. E. A. Chapin says: "The names in current use for the coccinellids related to *Cryptognatha* are retained in this paper. It is probable that the species here referred to *Cryptognatha, Serangium,* and *Delphastus* are all subject to generic reassignment."

largely in that stage, or upon the larvæ and pupæ. The pupal stage is passed in the soil or in rubbish beneath the tree. This predator was introduced into Cuba in 1930 and soon became established in the groves infested with *A. woglumi.* In several instances complete control was effected in heavily infested groves within three to five months after liberation of the beetles. Such a result, however, is only occasional, and greater reliance has been placed upon the eulophid parasite *Eretmocerus serius.* A species of *Cryptognatha*(3) was introduced into Japan from southern China as a predator of *Aleurocanthus spiniferus. Cryptognatha flavescens* is recorded by Woglum(6) as a predator of *Dialeurodes citri* in India, and an attempt was made to introduce it into the United States for the control of this pest.

Other coccinellid predators recorded as attacking Aleyrodidæ are *Serangium* sp. upon *Dialeurodes citri* in Japan and *Brumus suturalis* on the same host in India.

The nitidulid *Cybocephalus* sp. was found in only a single instance as a predator of Aleyrodidæ. This was in a mixed infestation of *Aleurocanthus citriperdus* and *A. woglumi* upon an orange tree at Buitenzorg, Java. All stages were present in considerable numbers. The larvæ are white and greatly resemble those of *Scymnus,* though they bear no dorsal covering of cast skins. They are sluggish and seldom leave the leaf upon which they first start feeding. Pupation takes place in a cell in the soil.

The dipterous family Drosophilidæ includes a number of species which are predacious upon Aleyrodidæ. *Acletoxenus indica* was found to be rather common in infestations of various species of *Aleurocanthus* and other genera in Java. Where several host species were present upon the same or adjoining trees a marked preference was shown for *A. citriperdus.* At Bandoeng, Java, *indica* was the most abundant of all predators upon the above host. The eggs are deposited among the host clusters and the *Acletoxenus* larvæ feed largely on the mature larvæ and pupæ, finally pupating upon the leaf surface. The puparia of *Acletoxenus* are heavily parasitized by *Myiocnema* sp. *Acletoxenus* sp. nov. was found to attack *Aleurocanthus citriperdus* and *A. woglumi* at Kaban Djahné, Sumatra, and empty puparia of some species of this genus were found among aleyrodid clusters in Malaya and Ceylon.

In practically every section larvæ of the Chrysopidæ are recorded as feeding upon the Aleyrodidæ, and often they are dominant among the predators attacking them. In only one in-

stance has the species been determined, this being *Chrysopa fulvolineata* attacking *Aleurocanthus spiniferus* in India.

The pyralid moth *Cryptoblabes gnidiella* was observed as an occasional predator on *Aleurocanthus citriperdus* and *A. woglumi* in Malaya and Sumatra. The larvæ feed upon the advanced stages of the host, and they may assume the rôle of scavengers also. In view of the record of its being a plant feeder in Egypt and southern Europe, and of its being possibly a predator on the cotton bollworm (*Earias insulana* Boisduval) in Egypt, *C. gnidiella* appears to be lacking in a fixity of habit.

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# NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XVIII [1]

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THREE PLATES

The crane flies discussed herein have been derived from a variety of sources, but chiefly from western China, where they were collected by the Rev. Mr. George M. Franck, and from Japan and Formosa, where taken by Mr. Syûti Issiki. Types of such species are preserved in my collection, through the kind interest of the collectors. Other specimens discussed are included in the Russian Academy of Sciences, Leningrad, through Drs. Pleske and von Stackelberg; in the Macleay Collection of the University of Sydney, through Mr. Frank H. Taylor; Federal Collection at Canberra, Australia, through Dr. Ian Mackerras; Bishop Museum, Honolulu, through Mr. Edwin H. Bryan; and Sumatran material collected by Mr. Edward Jacobson, now preserved in the United States National Museum, through the interest of the collector. As before, I am greatly indebted to all of the scientists mentioned, for their continued interest in saving these flies.

Among the Tipulidæ collected by Mr. Issiki in Hokkaido and Honshiu, Japan, were included a number of interesting records that are listed herewith.

*Sôunkyô, Hokkaido, June 4, 1932* (*S. Issiki*).

*Limonia* (*Limonia*) *fusca* Meigen.
*Pedicia* (*Nasiternella*) *hokkaidensis* sp. nov.
*Pedicia* (*Tricyphona*) *optabilis* Alexander.
*Pedicia* (*Tricyphona*) *seticauda* Alexander.
*Dicranota* (*Rhaphidolabis*) *spina* Alexander.
*Pseudolimnophila mobilis* sp. nov.
*Limnophila* (*Prionolabis*) *sounkyana* sp. nov.
*Ormosia takeuchii* Alexander.

[1] Contribution from the entomological laboratory, Massachusetts State College.

*Yumoto, Shimotsuke, Honshiu, altitude 4,850 feet, June 20, 1932* (*S. Issiki*).

*Limonia* (*Limonia*) *euphileta* Alexander.
*Dicranota* (*Rhaphidolabis*) *platymera* sp. nov.
*Pseudolimnophila yumotana* sp. nov.
*Limnophila* (*Limnophila*) *japonica* Alexander.
*Limnophila* (*Tricholimnophila*) *prionolaboides* sp. nov.
*Ormosia rectangularis* sp. nov.
*Erioptera* (*Hoplolabis*) *asiatica* Alexander.
*Molophilus pegasus* Alexander.
*Molophilus triacanthus* sp. nov.

*Lake Chuzenji, Shimotsuke, Honshiu, altitude 4,100 feet, June 22, 1932* (*S. Issiki*).

*Pseudolimnophila erecta* sp. nov.
*Limnophila* (*Prionolabis*) *inermis* sp. nov.
*Limnophila* (*Prionolabis*) *odai* Alexander.
*Limnophila* (*Tricholimnophila*) *saitamæ* Alexander.

*Konseitoge, Shimotsuke, Honshiu, altitude 5,200 to 6,500 feet, June 21, 1932* (*S. Issiki*).

*Limonia* (*Dicranomyia*) near *depauperata* Alexander.
*Pseudolimnophila erecta* sp. nov.
*Limnophila* (*Prionolabis*) *luteibasalis* sp. nov.

## LIMONIINÆ

### LIMONIINI

**LIMONIA (LIMONIA) FUSCA Meigen.**

*Limonia fusca* MEIGEN, Klassification 1 (1804) 54.
*Limnobia turpis* WALKER, Insecta Britannica, Diptera 3 (1856) 300.
*Dicranomyia pubipennis* OSTEN SACKEN, Proc. Acad. Nat. Sci. Philadelphia for 1859 (1859) 211.
*Limnobia pilipennis* EGGER, Verh. Zool.-Bot. Ges. Wien 13 (1863) 1108.

Two males, Sôunkyô, Hokkaido, Japan, June 4, 1932 (*S. Issiki*). This wide-spread Holarctic crane fly has not hitherto been recorded from eastern Asia.

**LIMONIA (LIBNOTES) FIJIENSIS DELANDI subsp. nov.**

*Male.*—Length, about 6 millimeters; wing, 7.

Sclerites of mesonotum behind the transverse suture almost uniformly darkened. Wings with dark pattern reduced, the stigma much smaller than in males of typical *fijiensis*. Venation: Sc long, $Sc_1$ ending beyond r-m, $Sc_2$ some distance from its tip, opposite fork of Rs; Rs unusually short and only slightly arcuated, about two-thirds as long as the corresponding vein in *fijiensis*. Male hypopygium with the caudal border of tergite evenly, convexly rounded, with a tiny median notch; setæ at the

exact border, those nearest the median notch more or less decussate. Basistyle with ventral-apical lobe long and slender, exceeding in length the basistyle itself, with four or five setæ at midlength more elongate and powerfully constructed; apex of lobe microscopically transverse-corrugated. Dististyle broad, at base with a small bisetiferous tubercle and a tiny acute spine; apical teeth approximated, the outer one slender. Gonapophyses elongate.

*Habitat.*—Santa Cruz Islands.

Holotype, male, Vanikoro Island (*C. M. Deland*). Received through Mr. Frank H. Taylor, to whom the type has been returned.

The present fly seems to be closest to *Limonia* (*Libnotes*) *fijiensis hebridensis* (Edwards), of New Hebrides, differing in the even shorter Rs and in the details of the male hypopygium. Whether the *fijiensis* group will be found to include several closely allied and vicarious species (as *toxopei* Edwards, of Buru; *veitchiana* Edwards, of Fiji, additional to the forms mentioned above) or whether these are best considered as being geographic races, cannot be affirmed without much more material than has yet been available. Edwards[2] has reported a variety of *fijiensis* from Samoa. He describes the apical lobe of the basistyle as being much shorter than in *fijiensis*, as figured by me,[3] whereas in the present fly it is distinctly longer.

LIMONIA (DICRANOMYIA) AMURENSIS (Alexander).

*Dicranomyia amurensis* ALEXANDER, Proc. U. S. Nat. Mus. **68** art. 4 (1925) 5–6, fig. 1 (male hypopygium).

Described from a single male, Amagu Village, Ussuri, July 1923 (*T. D. A. Cockerell*). An additional male, Kuegda, Saghalien, July 10, 1908 (*W. Soldatov*); Academy of Sciences, Leningrad.

A few supplementary notes are given: Thoracic pleura gray, the dorsopleural region more infuscated. Venation: m-cu about one-third its length before fork of M. Male hypopygium about as described and figured in original definition, with certain emendations. Cephalic mesal margin of ventral dististyle, below base of rostral prolongation with a conspicuous group or pencil of setæ. Apex of basistyle on mesal face with a dense group of setæ.

[2] Insects of Samoa, Diptera Nematocera (1928) 80–81.

[3] Ann. Ent. Soc. America 7 (1914) 246, fig. 8.

The species is allied to the Nearctic *gibsoni* (Alexander), *hæretica* (Osten Sacken), and *penicillata* (Alexander), but is still very different in the structure of the male hypopygium.

**LIMONIA (DICRANOMYIA) PLATYROSTRA (Alexander).**

*Dicranomyia platyrostra* ALEXANDER, Can. Ent. 59 (1927) 223–224, fig. 2 (male hypopygium).

This species was described from the Lesser Slave Lake, Alberta, Canada, taken in mid-August by Owen Bryant. In the Academy of Sciences, Leningrad, a male from Shiveluch Volcano, near Nizchnekamchatsk, Kamchatka, 162° 30′ east longitude, 56° 40′ north latitude, August 27, 1909 (*P. Schmidt*).

This has been compared with the type, and I can see no differences with the single exception that the rostral spines are a little shorter in the present specimen than in the type.

**LIMONIA (GERANOMYIA) UNIFILOSA sp. nov.** Plate 1, fig. 1; Plate 2, fig. 25.

General coloration of thorax bluish gray, the præscutum with a darker median stripe; head blackish, the posterior vertex with a narrow grayish median line; legs yellow; wings with a brown pattern, including small marginal clouds at ends of outer medial veins; m-cu close to fork of M; male hypopygium with the rostral prolongation bearing a single, very slender spine; gonapophyses with lateral tooth on mesal-apical lobe.

*Male.*—Length, excluding rostrum, about 6 millimeters; wing, 6.3; rostrum, about 2.

Rostrum black throughout; palpi black. Antennæ black; flagellar segments oval. Head blackish, the posterior vertex with a narrow grayish median line, extending caudad onto the occiput.

Mesonotal præscutum above bluish gray, with deep reddish tints; a broad median blackish stripe, the lateral margins apparently similarly darkened, but the coloration changeable in different lights; posterior sclerites of mesonotum darkened, the scutellum with a darker median area. Pleura blackish, the sternopleurite brightened to reddish. Halteres pale, the knobs dusky. Legs with the coxæ and trochanters yellow, the posterior coxæ somewhat darker; remainder of legs pale yellow, the outer tarsal segments a trifle darker. Wings (Plate 1, fig. 1) broad, the ground color pale brownish; a moderately heavy brown pattern, chiefly costal in distribution, but including smaller marginal spots at ends of all longitudinal veins; second area (at supernumerary crossvein in cell Sc) reaching vein M; stigmal area produced backward to vein $R_{4+5}$; apical darkenings

in outer radial and medial fields forming a broken, nearly terminal band; narrow brown seams along cord and outer end of cell 1st $M_2$; veins pale yellow, darker in the clouded areas. Venation: $Sc_1$ ending about opposite three-fourths the length of Rs, $Sc_2$ near its tip; a supernumerary crossvein in cell Sc; free tip of $Sc_2$ and $R_2$ subequal; m-cu close to fork of M.

Abdominal tergites dark brown, sternites more reddish; hypopygium dark. Male hypopygium (Plate 2, fig. 25) with the tergite, *9t*, transverse, the caudal margin deeply emarginate, the lateral lobes obtusely rounded. Basistyle, *b*, relatively small, the ventromesal lobe of moderate size. Dorsal dististyle strongly curved at near two-thirds the length. Ventral dististyle, *vd*, fleshy, larger than the basistyle; rostral prolongation long and stout, bearing a single long, very slender spine from an enlarged basal tubercle close to tip of prolongation; no trace of a second rostral spine. Gonapophyses, *g*, with the mesal-apical lobe long, obtuse at tip, bearing a slender erect spine at near midlength. Ædeagus, *a*, large, the apex distinctly bilobed.

*Habitat.*—Formosa.

Holotype, male, Shinten, near Taihoku, December 12, 1929 (*S. Issiki*).

The present fly is closest to *Limonia* (*Geranomyia*) *septemnotata* (Edwards), of Formosa, and *L.* (*G.*) *tenuispinosa* (Alexander), of eastern China. The former is still known only from the unique type female, taken in the high mountains; it differs in the coloration of the head and pleura, the pale brown legs, and the details of wing pattern, especially the coloration of the outer medial field. The latter fly has a somewhat similar male hypopygium but a very different wing pattern and venation. The single very slender spine of the rostral prolongation of the male hypopygium of the present species is very different from that of all other regional members of the subgenus, though suggested by *tenuispinosa,* where the second spine lies near the base of the prolongation and is small, tending to be reduced. The possibility exists that such a spine occurs in the present fly and is broken, but I can detect no trace of its former presence.

LIMONIA (GERANOMYIA) BALIANA sp. nov. Plate 1, fig. 2; Plate 2, fig. 26.

Allied and generally similar to *javanica;* general coloration of præscutum dark brown, almost covered by three light gray stripes, the median one split by a capillary brown median vitta; scutellum gray; halteres pale yellow; femora obscure yellow, the tips brownish black; wings whitish, with a dark brown,

chiefly costal pattern; male hypopygium with the tergite deeply notched medially; ventral dististyle very large and fleshy, the rostral spines arising from a long and powerful common basal tubercle, the outer spine from a smaller, slenderer tubercle.

*Male.*—Length, excluding rostrum, about 7 millimeters; wing, 7.2; rostrum, about 2.

Rostrum relatively short and stout, black, the surface with short erect setulæ. Antennæ black throughout; basal flagellar segments short-cylindrical, the outer more elongate, suboval; terminal segment subequal to penultimate. Anterior vertex light gray, the posterior vertex brownish black, divided medially by a narrow gray line extended backward from the anterior vertex.

Ground color of præscutum dark brown almost covered by three light gray stripes, the median one split by a capillary median brown vitta that ends at the suture; lateral interspaces reduced to narrow lines; scutum gray, the mesal edge of each lobe with a dark brown line; scutellum gray; mediotergite gray, with a brown median triangle, the point directed caudad. Pleura more or less darkened dorsally, the sternopleurite and pleurotergite light gray. Halteres pale yellow. Legs with the coxæ and trochanters greenish yellow; femora obscure yellow, the tips brownish black; tibiæ and basitarsi yellowish brown, the tips narrowly dark brown; terminal tarsal segments black. Wings (Plate 1, fig. 2) with the ground color whitish, with a dark brown, chiefly costal pattern, that is arranged about as in *javanica;* pale interspaces more extensive than in the latter, the darkened area at midlength of cell Sc conspicuously narrowed in cell R; dark area at end of vein $R_3$ with a small pale central spot above the tip of vein; no darkening in cell $R_5$ beyond cord; veins brown, somewhat darker in the infuscated areas. Venation: $Sc_2$ ending distinctly beyond midlength of the angulated and weakly spurred Rs; m-cu at fork of M.

Abdominal tergites dark brown, the caudal borders of the intermediate segments somewhat paler. Male hypopygium (Plate 2, fig. 26) with the tergite, *9t,* deeply notched medially, the rounded lobes with numerous setæ of moderate length. Basistyle, *b,* small. Ventral dististyle, *vd,* very large and fleshy, its area several times that of the basistyle; rostral prolongation small, with a conspicuous armature, consisting of a long fused basal tubercle bearing two powerful curved spines, the outermost of which arises from a further swollen basal portion; under

high magnification, each of these spines has a median split throughout the length, being apparently formed from the fusion of two slenderer spines. Dorsal dististyle small, sickle-shaped, subequal to the rostral spines. Gonapophyses, *g*, with the mesal-apical blade flattened, its margin with microscopic denticles. Ædeagus, *a*, with numerous delicate setulæ on either side back from tip.

*Habitat.*—Bali.

Holotype, male, July 1–2, 1929 (*I. M. Mackerras*).

*Limonia* (*Geranomyia*) *baliana* is closest to *L.* (*G.*) *javanica* (Alexander), of western Java, differing chiefly in the colorational details, as the yellow halteres and the conspicuous whitish ground color of the wings. The male sex of *javanica* is still unknown and the hypopygium will very probably yield other characters, since it belongs to a group that shows great diversity in hypopygial details. The general type of hypopygium of the present fly, with two rostral spines arising from a long common basal tubercle, is found in several other Oriental and eastern Palæarctic species of the subgenus, as *L.* (*G.*) *apicifasciata* (Alexander), *L.* (*G.*) *immobilis* (Alexander), *L.* (*G.*) *multipuncta* (Alexander), *L.* (*G.*) *phœnosoma* (Alexander), and others, but all details are quite distinct.

### LIMONIA (GERANOMYIA) JAVANICA KOCKENSIS subsp. nov.

Characters as in typical *javanica* Alexander (western Java), differing in colorational details, especially the gray sternopleurite and sternum and the black legs.

Posterior vertex blackened, with a median gray line that is a caudal extension of the narrow anterior vertex. Pleura entirely gray, the dorsal sclerites darker. Halteres yellow, the knobs dark brown. Legs beyond the trochanters black, only the femoral bases very narrowly and restrictedly paler. Abdominal sternites obscure yellow.

*Habitat.*—Sumatra.

Holotype, female, Fort de Kock, altitude 3,000 feet, 1925 (*E. Jacobson*). Paratopotype, female.

### LIMONIA (GERANOMYIA) VANIKORENSIS sp. nov. Plate 1, fig. 3.

General coloration of mesonotal præscutum chestnut brown, paler laterally; rostrum, palpi, and antennæ black, legs dark brown to black; wings grayish subhyaline, with about six small costal and subcostal darkenings, the last two at ends of veins $R_3$ and $R_{4+5}$; Rs angulated near origin.

*Female.*—Length, excluding rostrum, about 6.5 millimeters; wings, 7.2; rostrum, about 3.2.

Rostrum elongate, black throughout; palpi 1-segmented. Antennæ black throughout; flagellar segments subcylindrical, not or scarcely decreasing in length outwardly, the last elongate. Head black, the narrow anterior vertex light gray, the color continued back onto the mid-region of posterior vertex as a narrow line.

Pronotum brownish black, paler laterally. Mesonotal præscutum deep chestnut brown on disk, the humeral and lateral portions more yellowish; scutal lobes dark brown, the median region and scutellum more testaceous; mediotergite reddish testaceous. Pleura chiefly reddish brown. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters reddish testaceous; remainder of legs dark brown to black, the femoral bases a little paler. Wings (Plate 1, fig. 3) grayish subhyaline, with about six small costal and subcostal darkenings, the first at the supernumerary crossvein in cell Sc, the second at origin of Rs, third at fork of Sc; fourth, paler, the small subcircular stigma; last two areas at ends of veins $R_3$ and $R_{4+5}$; cord and outer end of cell 1st $M_2$ narrowly seamed with paler brown; veins brown, somewhat darker in the clouded areas. Venation: A weak supernumerary crossvein in cell Sc; vein Sc relatively long, $Sc_1$ ending shortly before fork of Rs, $Sc_2$ at its tip; free tip of $Sc_2$ and $R_2$ about in transverse alignment; Rs from about two and one-half to nearly three times as long as the basal section of $R_{4+5}$, markedly angulate near origin; m-cu shortly beyond fork of M.

Abdomen chiefly dark brown, the genital region more yellowish. Ovipositor with cerci moderately long, nearly straight, the tips broadly and obtusely rounded.

*Habitat.*—Santa Cruz Islands.

Holotype, female, Vanikoro Island (*C. M. Deland*). Received through Mr. Frank H. Taylor, to whom the type has been returned.

The only other member of the subgenus from the smaller and more-remote Pacific Islands is *Limonia* (*Geranomyia*) *samoana* (Edwards), of Samoa, which is the species most generally similar to the present fly. It differs in the details of body coloration, wing pattern, and venation. *Limonia* (*G.*) *sagittifer* (Alexander), of North Queensland, is also somewhat closely allied to both of the above, yet evidently distinct by the coloration of the body and wings and in the venational details.

**LIMONIA (PSEUDOGLOCHINA) BRYOPHILA** sp. nov. Plate 1, fig. 4; Plate 2, fig. 27.

Mesonotum dark brown, the cephalic and lateral portions of præscutum abruptly yellowish white; a narrow pale median vitta extends from the præscutum to base of abdomen; pleura yellowish white, the sternopleurite and fore coxæ dark brown; tibiæ with two narrow dark rings, widely separated; wings with a strong brown tinge, the costal region still darker; $Sc_1$ ending opposite or before midlength of Rs; medial forks short; vein 2d A relatively long and extended.

*Male.*—Length, about 5.5 millimeters; wing, 6.

*Female.*—Length, about 5.5 to 6 millimeters; wing, 6 to 6.5.

Rostrum brown; palpi brownish black. Antennæ brownish black throughout, nodulose, the individual flagellar segments oval, with short but distinct necks. Head pale yellowish brown.

Pronotum pale yellow. Mesonotum chiefly dark brown, the projecting præscutum abruptly pale yellowish white on front and sides; a narrow capillary pale line begins on the præscutum, extending caudad to abdomen, widest on the scutellum and base of mediotergite. Pleura almost entirely yellowish white, contrasting abruptly with the mesonotum; ventral sternopleurite dark brown. Halteres dark brown. Legs with the fore coxæ and trochanters dark brown, the remaining coxæ and trochanters pale yellow; forelegs broken; mid-femora dirty white, becoming clearer on outer third, the tip very narrowly darkened; posterior femora white, the distal fifth abruptly blackened; tibiæ pure white, with two very narrow, subequal, brownish black rings, the distance between them about equal to six or seven times the width of either ring; tarsi white. Wings (Plate 1, fig. 4) with a strong brown tinge, the costal region more saturated; stigma oval, dark brown; a small brown cloud at origin of Rs; veins brown. Venation: Sc ending opposite or just before midlength of Rs; Rs and basal section of $R_{4+5}$ only slightly oblique in position; medial forks short; m-cu variable in position, in cases about one-half its length before fork of M; vein 2d A relatively long and extended.

Abdominal tergites dark brown, the sternites pale yellow; outer sternites more or less darkened basally. Male hypopygium (Plate 2, fig. 27) with the tergite, *9t*, shallowly notched. Dorsal dististyle pale yellow. Ventral dististyle, *vd*, large and fleshy, much exceeding the basistyle in size, the rostral prolongation with a single pale spine. Gonapophyses, *g*, with mesal-apical lobe stout.

*Habitat.*—China (Szechwan).

Holotype, male, Mount Omei, on mossy cliffs in river gorge, altitude 3,600 feet, July 27, 1932 (*Franck*). Allotopotype, female. Paratopotype, female.

The closest ally of the present fly is *Limonia* (*Pseudoglochina*) *riukiuensis* Alexander (Japan: Riukiu Islands), which differs in the more oblique anterior cord, deeper medial forks, and more elongate and extended vein 2d A. The macrotrichia of the wing veins in *riukiuensis* are longer and more abundant, including nearly the outer half of M and the outer end of the basal section of $Cu_1$. The present fly was associated on mossy cliffs with specimens of the superficially rather similar *Limonia* (*Limonia*) *unicinctifera* Alexander.

**ORIMARGA (ORIMARGA) NUDIVENA** sp. nov. Plate 1, fig. 5; Plate 2, fig. 28.

General coloration dark grayish brown, the ventral surfaces of thorax and abdomen reddish; antennæ black; wings broad; costal fringe (male) long and conspicuous; macrotrichia of veins very sparse, lacking on $R_3$; $R_{1+2}$ about twice $R_2$, the latter subequal to $R_{2+3}$; vein 2d A elongate; male hypopygium with the armature of the phallosome conspicuously developed as spinous points.

*Male.*—Length, about 4.5 millimeters; wing, 5.

Rostrum reddish brown. Antennæ black throughout; flagellar segments short-oval. Head dark gray.

Mesonotum grayish brown, the præscutum indistinctly striped. Pleura reddish brown. Halteres brown. Legs with coxæ and trochanters reddish; remainder of legs black. Wings (Plate 1, fig. 5) broad, widest opposite level of outer end of cell 1st A; color grayish, veins pale brown. Costal fringe very long and erect; macrotrichia of veins very sparse, with a scattered series on vein R, distal section of $R_5$ and outer end of $M_{1+2}$; no trichia on vein $R_3$. Venation: $R_{1+2}$ about twice $R_2$, the latter subequal to $R_{2+3}$; basal section of $R_{4+5}$ angulated at origin; vein 2d A elongate, ending opposite level of m-cu.

Abdominal tergites dark brown, the sternites reddish. Male hypopygium (Plate 2, fig. 28) with the armature of the phallosome, *p*, well-developed and conspicuous.

*Habitat.*—China (Szechwan).

Holotype, male, Mount Omei, altitude 3,000 feet, July 8, 1932 (*Franck*).

*Orimarga* (*Orimarga*) *nudivena* is well-distinguished from all regional allies by the unusual glabrousness of the wing veins

and the conspicuous development of the phallosomic region of the male hypopygium.

ORIMARGA (ORIMARGA) ÆQUIVENA sp. nov. Plate 1, fig. 6.

General coloration of body blackish gray; wings with a grayish tinge; costal fringe of moderate length in both sexes; macrotrichia of veins numerous, including a complete series on vein $R_3$; $R_{2+3}$ and $R_2$ subequal.

*Male.*—Length, about 4.5 millimeters; wing, 4.

*Female.*—Length, about 5 millimeters; wing, 4.6.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval. Head dark gray.

Thorax dark blackish gray, the præscutum without stripes. Halteres pale, the knobs blackish. Legs with the fore coxæ brownish black, the remaining coxæ somewhat paler; trochanters pale brown; femora light yellowish brown, the tips dark brown; tibiæ and tarsi pale brown, the outer tarsal segments blackened. The legs are more uniformly blackened in the female. Wings (Plate 1, fig. 6) with a grayish tinge, darker in the female; veins brown. Costal fringe of moderate length only; macrotrichia of veins short but numerous, including complete series on veins $R_3$, $R_{4+5}$, $M_3$, $M_4$, and all of $M_{1+2}$ except the base. Venation: $Sc_1$ ending opposite two-thirds Rs, $Sc_2$ near its tip; $R_{2+3}$ subequal to $R_2$, the latter a little longer than $R_{1+2}$; free tip of $Sc_2$ pale but evident, $R_1$ subequal to $R_{1+2}$; forks of medial cells of moderate depth; m-cu opposite basal fourth or fifth of Rs. In the female, $R_{1+2}$ is longer, being nearly twice $R_2$ alone; medial forks deeper.

Abdomen brownish black, the sternites a trifle brighter.

*Habitat.*—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,200 feet, July 5, 1932 (*Franck*). Allotype, female, altitude 4,800 feet, July 4, 1932 (*Franck*). Paratypes, altitude 4,200 feet, June 29 to July 5, 1932; altitude 4,800 feet, July 4, 1932.

Of the species of *Orimarga* so far discovered in western China, the only species with a somewhat similar venation is *O.* (*O.*) *cruciformis* Alexander, which is readily told by the unusually long narrow wings, with long basal petiole and with a cruciform arrangement of veins at end of Rs. The Formosan species *O.* (*O.*) *fuscivenosa* Alexander and *O.* (*O.*) *taiwanensis* Alexander have a somewhat similar arrangement of veins in the radial field, but are distinguishable by the shape of the wing and the venation, *fuscivenosa* having the wings unusually narrow, cell

$M_3$ deeper, and cell 2d A narrower; *taiwanensis* differs in the yellowish wings, with pale veins, and in the slightly different venational details.

PEDICIINI

**PEDICIA (NASITERNELLA) HOKKAIDENSIS** sp. nov. Plate 1, fig. 7; Plate 2, fig. 29.

Allied to *hyperborea;* mesonotal præscutum yellowish gray, with four dark brown stripes; legs with femora obscure yellow to brownish yellow, the tips narrowly dark brown; wings yellowish, heavily patterned with brown; costal darkenings between $Sc_2$ and origin of Rs widely separated, between Rs and tip of $Sc_1$ narrowly separated; male hypopygium with setæ at end of arm of basistyle relatively short and inconspicuous; interbase with outer end suddenly narrowed.

*Male.*—Length, about 11 to 12 millimeters; wing, 11 to 11.5.

Rostrum and palpi dark brown. Antennæ broken. Head dark gray.

Mesonotal præscutum yellowish gray, with four dark brown stripes, the intermediate pair only narrowly separated, confluent at anterior ends, the posterior ends not reaching the suture; scutal lobes variegated with dark brown; scutellum dark brown, obscure yellow beneath; mediotergite dark brownish gray. Pleura brownish gray. Halteres broken. Legs with coxæ pale, darker basally, more extensively so on posterior legs; trochanters yellow; femora obscure yellow to brownish yellow, the tips narrowly dark brown; tibiæ pale brown, the tips very narrowly dark brown; tarsi pale brown, the outer segments darker. Wings (Plate 1, fig. 7) with the ground color strongly yellowish, heavily patterned with brown, chiefly as large marginal clouds at ends of all longitudinal veins; areas at $Sc_2$ and origin of Rs widely separated, the pale area between fully as wide as either dark area; pale costal area between origin of Rs and tip of $Sc_1$ reduced in size. Venation: Rs relatively short, angulated at origin; m present (in types).

Abdomen dark brown. Male hypopygium (Plate 2, fig. 29) much as in *hyperborea;* setæ at apex of the long slender arm of basistyle, *b,* short and inconspicuous. Interbase, *i,* broad basally, the outer half or less suddenly narrowed.

*Habitat.*—Japan (Hokkaido).

Holotype, a broken male Sôunkyô, June 4, 1932 (*S. Issiki*). Paratopotype, a broken male.

*Pedicia* (*Nasiternella*) *hokkaidensis* is allied to but obviously distinct from the Nearctic *P.* (*N.*) *hyperborea* (Osten Sacken),

differing in the characters listed above. I am not in possession of a specimen of *P.* (*N.*) *variinervis* (Zetterstedt), type of the subgenus, and know the species only from Wahlgren's notes and figures of the Zetterstedt types.[4] There are a few important distinctions shown in the figures that apparently do not enter into the general plasticity of venation of the species; that is, the arcuate Rs, long and conspicuous basal section of $R_{4+5}$, and proportionately short second section of the latter vein. In the light of the evident distinctness of *hyperborea,* I believe the male hypopygium of the present species and *variinervis* will likewise show differences when the latter becomes available for comparison. In 1933, it was first detected that *hyperborea* had a subapterous female and it seems certain that the two Palæarctic species above discussed will be found likewise to agree in this respect.

**DICRANOTA (RHAPHIDOLABIS) PLATYMERA** sp. nov. Plate 1, fig. 8; Plate 2, fig. 30.

General coloration gray, the præscutum with three darker grayish brown stripes; antennæ 12-segmented, black throughout; legs pale, the femoral tips darker; wings milky white, the stigma scarcely indicated; cell $R_3$ sessile; abdomen brown, the hypopygium a little brighter; male hypopygium with the lateral tergal arms appearing as acute spines, the median area convex; interbase flattened, the apex an acute spine.

*Male.*—Length, about 4.5 to 5 millimeters; wing, 6 to 6.5.

Rostrum and palpi brown. Antennæ black throughout, 12-segmented; flagellar segments oval, the terminal segment more elongate. Head dark gray.

Mesonotum gray, the præscutum with three darker grayish brown stripes. Pleura chiefly pale. Halteres pale, the knobs weakly darkened. Legs with the coxæ and trochanters pale; femora yellow, the tips passing into pale brown; tibiæ and tarsi pale yellowish brown, the terminal segments of the latter darkened. Wings (Plate 1, fig. 8) milky white; stigma not or scarcely indicated; veins pale brown. Venation: Rs arcuated; cell $R_3$ sessile; $R_{1+2}$ short to punctiform; cell $M_2$ open.

Abdomen dark brown, the hypopygium brighter. Male hypopygium (Plate 2, fig. 30) with the median region of tergite, *9t,* broadly convex; lateral arms appearing as acute simple spines. Interbasal process, *i,* flattened, the outer margin microscopically serrulate, the apex directed laterad into an acute spine.

[4] Arkiv för Zoologi 2 No. 7 (1904) 4, figs. 1–3.

Apices of basistyle, *b*, and outer dististyle, *od*, with microscopic spines.

*Habitat*.—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Paratopotype, a fragmentary male.

The only near regional ally so far described is *Dicranota* (*Rhaphidolabis*) *spina* Alexander (Honshiu, Hokkaido), which is well-distinguished by hypopygial characters, notably the shape of the interbasal process.

HEXATOMINI

**PSEUDOLIMNOPHILA MOBILIS** sp. nov. Plate 1, fig. 9; Plate 2, fig. 31.

General coloration of thorax dark gray, the dorsopleural region buffy; middle and posterior coxæ chiefly pale; posterior femora obscure yellow, the tips narrowly darkened; wings tinged with yellow; small, pale brown clouds at origin of Rs, along cord, outer end of cell 1st $M_2$, and in axillary region; $R_2$ lacking or very poorly indicated; abdomen dark brown, the caudal borders of the intermediate segments pale.

*Male*.—Length, about 8 millimeters; wing, 8.

Rostrum gray; palpi black. Antennæ brownish black throughout; flagellar segments long-oval. Head light gray.

Thorax dark, blackish gray, the præscutum without stripes; dorsopleural region more buffy. Halteres pale yellow. Legs with the fore coxæ darkened, the other coxæ chiefly pale; trochanters yellow; femora obscure yellow, the tips narrowly darkened (only posterior legs remaining); tibiæ light brown, the tips narrowly blackened; tarsi black. Wings (Plate 1, fig. 9) tinged with yellow, the prearcular and costal regions clearer yellow; stigma elongate-oval, brown; small and ill-delimited pale brown clouds at origin of Rs, cord and outer end of cell 1st $M_2$; axillary region narrowly darkened; veins brown, the prearcular field light yellow. Venation: Both $Sc_1$ and $Sc_2$ ending before level of fork of Rs; $R_2$ lacking or so faintly indicated as to be scarcely visible, approximately in the position indicated in figure; region of stigma with no interruption of the microtriehia in this field; m-cu at midlength of cell 1st $M_2$.

Abdomen dark brown, the caudal borders of the intermediate segments narrowly pale; ninth segment dark. Male hypopygium (Plate 2, fig. 31) with the notch of the tergite, *9t*, relatively shallow. Basistyle, *b*, simple. Outer dististyle, *od*, with the apical spine moderately blackened. Interbase, *i*, bispinous, as figured.

*Habitat.*—Japan (Hokkaido).

Holotype, male, Sôunkyô, June 4, 1932 (*S. Issiki*).

*Pseudolimnophila mobilis* is most closely allied to *P. horii* Alexander in the dark gray color of the thorax and general coloration of the wings. The slightly patterned wings, with the details of venation distinct, together with the structure of the hypopygium, especially the basistyle and interbase, should readily separate the present fly from other similar species.

**PSEUDOLIMNOPHILA YUMOTANA** sp. nov. Plate 1, fig. 10; Plate 2, fig. 32.

*Male.*—Length, about 8 millimeters; wing, 9.5.

Closely allied to *Pseudolimnophila horii* Alexander, differing especially in the conspicuously patterned wings and slight differences in the male hypopygium.

Mesonotum gray, the præscutum with three nearly confluent dark brown stripes. Pleura dark gray. Wings (Plate 1, fig. 10) with a grayish yellow tinge, patterned with brown, including the stigma, seams at origin of Rs, cord, outer end of cell 1st $M_2$, Cu, and in axillary region, the cubital darkening being especially conspicuous. Venation: $Sc_1$ ending opposite fork of Rs $Sc_2$ at its tip; $R_2$ slightly longer than $R_{1+2}$; distinct; $R_3$ strongly sinuous; m-cu erect, just beyond midlength of cell 1st $M_2$.

Male hypopygium (Plate 2, fig. 32) with the notch of the tergite, *9t*, U-shaped, unusually deep. Basistyle, *b*, with a triangular protuberance on mesal face near apex. Interbase, *i*, with the two spines lying parallel, the outer a little longer.

*Habitat.*—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*).

*Pseudolimnophila horii* has the wings unpatterned excepting for the stigma and a more or less evident darkening on the anterior cord.

**PSEUDOLIMNOPHILA ERECTA** sp. nov. Plate 1, fig. 11.

General coloration gray, the præscutum with four darker brownish gray stripes, the intermediate pair separated by a narrow line of the ground color; wings strongly tinged with yellow, sparsely patterned with brown; Sc short, $Sc_1$ ending before fork of Rs; $R_{2+3+4}$ short and suberect, subequal in length to m-cu.

*Female.*—Length, about 8 to 9 millimeters; wing, 8 to 9.

Rostrum gray; palpi black. Antennæ black; flagellar segments elongate, fusiform. Head dark gray.

Mesonotum dark gray, with four narrow darker brownish gray stripes, the intermediate pair separated by a line of the ground color about equal in width to the stripes themselves. Pleura gray, the dorsopleural region chiefly darkened. Halteres yellow. Legs with the coxæ entirely clear gray (holotype) or with the tips yellow, on posterior legs including most of coxæ (paratype); trochanters yellow; femora and tibiæ obscure yellow, the tips passing into dark brown; tarsi light brown, the outer segments darker. Wings (Plate 1, fig. 11) strongly tinged with yellow, especially in the type, the prearcular and costal regions more conspicuously luteous; stigma and a cloud on anterior cord darkened; in holotype, a dark cloud at origin of Rs; in paratype, vein Cu evidently seamed with pale brown; veins pale, more yellowish in the luteous areas. Venation: Sc short, $Sc_1$ ending before fork of Rs, $Sc_2$ at its tip; $R_2$ and $R_{1+2}$ distinct and subequal in length; $R_{2+3+4}$ unusually short and suberect in position, subequal to m-cu; $R_3$ not conspicuously arched on basal half; basal section of $R_{4+5}$ short to very short; petiole of cell $M_1$ subequal to or a little longer than m-cu, the latter at near two-thirds the length of cell 1st $M_2$.

Abdomen dark brown; shield of ovipositor brownish black; valves horn yellow, cerci relatively short.

*Habitat.*—Japan (Honshiu).

Holotype, female, Lake Chuzenji (Tzujenji), Shimotsuke, altitude 4,100 feet, June 22, 1932 (*S. Issiki*). Paratype, female, Konseitoge, Shimotsuke, altitude 5,200 to 6,500 feet, June 21, 1932 (*S. Issiki*).

In the gray coloration of the thorax, *Pseudolimnophila erecta* is most generally similar to *P. horii* Alexander and *P. yumotana* sp. nov., being separated by the presence of four præscutal stripes and by the venation, especially the short, elevated $R_{2+3+4}$.

**LIMNOPHILA (PRIONOLABIS) SÔUNKYANA sp. nov.** Plate 1, fig. 12; Plate 2, fig. 33.

General coloration black, the thorax subopaque to opaque by a gray pruinosity; male hypopygium with the notch of tergite evenly and shallowly rounded; both dististyles short, the inner only a little less than the outer.

*Male.*—Length, about 9 to 9.5 millimeters; wing, 10.5 to 11.

*Female.*—Length, about 9 millimeters; wing, 8.5 to 9.

Rostrum, palpi, and antennæ black, the latter 16-segmented in both sexes; basal segments with outer faces protuberant; outer segments passing into oval. Head dull black, sparsely gray pruinose.

Mesonotum black, the surface subopaque by a sparse pruinosity. Pleura somewhat more heavily pruinose. Halteres pale yellow. Legs with the coxæ and trochanters black; femora yellow, the tips blackened, most extensively so on forelegs where the outer three-fourths is included, more narrowly on the posterior legs where the outer fourth is darkened. Wings (Plate 1, fig. 12) with the stigma small and relatively inconspicuous; dark seams of wing extensive but pale and diffuse; venation of medial field variable, especially of cells near the cord.

Abdomen, including hypopygium, black. Male hypopygium (Plate 2, fig. 33) with the notch of tergite, *9t*, evenly rounded. Both dististyles (*od, id*) small and heavily blackened, the outer only a little longer than the inner.

*Habitat.*—Japan (Hokkaido).

Holotype, male, Sôunkyô, June 4, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 1 male, 1 female.

*Limnophila* (*Prionolabis*) *sôunkyana* is most closely allied to *L.* (*P.*) *neomunda* Alexander, likewise from Hokkaido, differing in the much larger size and details of structure of the hypopygium, especially of the dististyles. Of the fourteen Japanese and Formosan species of *Prionolabis* so far discovered, these two are most similar in the structure of the male hypopygium, but certainly appear to represent entirely distinct species.

**LIMNOPHILA (PRIONOLABIS) LUTEIBASALIS** sp. nov. Plate 1, fig. 13; Plate 3, fig. 34.

General coloration polished black; antennæ 13-segmented in both sexes; wings (female) reduced, light yellow on basal third, the remainder darker; wings (male) fully developed; cells $R_3$ and $M_1$ present; male hypopygium with caudal margin of tergite weakly trilobed.

*Male.*—Length, about 8 millimeters; wing, 9.

*Female.*—Length, about 7 millimeters; wing, 2.

*Female.*—Rostrum and palpi black. Antennæ black throughout, 13-segmented; flagellar segments oval, with verticils that exceed the segments; terminal segment elongate and evidently a fusion of segments, about one-half longer than the eighth flagellar segment; penultimate segment not clearly cut off from terminal segment, smaller than the antepenultimate. Head black, very sparsely pruinose; anterior vertex wide, the eyes correspondingly small.

Thoracic dorsum black, polished; pleura somewhat more pruinose. Halteres small, not exceeding one-half the length of

wings, dusky at base, the knobs clear yellow. Legs stout and hairy, brownish yellow, the femoral tips broadly blackened, somewhat more extensively so on forelegs; tibiæ yellowish brown, the tips darker; tarsi black. Wings reduced, stenopterous; basal third clear light yellow, the remainder suffused with dark brown, chiefly produced by the veins and adjoining membrane. Macrotrichia present on veins C and R, and as sparse groups on veins beyond cord. Venation distorted but showing Rs elongate; cell $R_3$ present and deep; cell $M_1$ present, small.

Abdomen black; ovipositor with valves unusually long and powerful, horn yellow, the cerci nearly straight with the tips gently upcurved.

*Male.*—Characters as in female, differing especially in the fully winged condition. Antennæ as in female, some of the intermediate segments showing traces of fusion. Halteres normally developed, pale, the knobs light yellow. Legs long and slender; fore femora with more than outer half blackened; hind femora with only the tips narrowly darkened. Wings (Plate 1, fig. 13) yellow, the prearcular and costal regions clearer yellow; stigma oval, brown; dark pattern on disk greatly reduced or lacking. Male hypopygium (Plate 3, fig. 34) with the central portion of tergite, *9t,* produced, its margin weakly trilobed. Inner dististyle, *id,* with two long slender spines that are closely appressed to the apical point.

*Habitat.*—Japan (Honshiu).

Holotype, female, Konseitoge, Shimotsuke, altitude 5,200 to 6,500 feet, June 21, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 2 broken females.

The only other species with reduced wings in the female sex is *Limnophila* (*Prionolabis*) *imanishii* Alexander (Japanese Alps), which has antennæ of similar segmentation and structure. The present fly has the wings of the female proportionately longer, broader at base, and with the conspicuous coloration above described. In *imanishii* the wings are yellowish brown throughout. The male sex appears to be correctly associated with its female. The reduced number of antennal segments in both sexes readily separates the present fly from all allies, including *L.* (*P.*) *odai* Alexander, the male hypopygium of which has a very similar ninth tergite.

**LIMNOPHILA (PRIONOLABIS) INERMIS** sp. nov. Plate 1, fig. 14; Plate 3, fig. 35.

Belongs to the *lipophleps* group; general coloration black; male hypopygium with the outer dististyle simple; gonapophysis narrowed to an acute apical point, before tip on outer margin with a crest of about five or six small subappressed spinules; on inner margin at about three-fourths the length with a single long acute spine.

*Male*.—Length, about 4 millimeters; wing, 5.5.

*Female*.—Length, about 4.5 millimeters; wing, 5 to 5.5.

Rostrum and palpi black. Antennæ black throughout; flagellar segments short-oval. Head black.

Pronotum and mesonotum black, the surface subnitidous. Pleura black, subopaque. Halteres broken. Legs with coxæ and trochanters black; remainder of legs brownish black to black, the femoral bases narrowly obscure yellow, a trifle more extensive on the posterior legs; legs relatively long and slender in both sexes. Wings (Plate 1, fig. 14) with a faint brown tinge; stigma oval, pale brown; veins pale brown. Venation: Cell $M_1$ lacking, as in the group; m-cu about one-half its length beyond fork of M.

Abdomen, including hypopygium, black. Male hypopygium (Plate 3, fig. 35) with the outer dististyle, *od*, simple, gradually narrowed to an acute, gently curved black point; inner dististyle narrowed into a long slender apical point. Gonapophyses, *g*, as figured.

*Habitat*.—Japan (Honshiu).

Holotype, male, Lake Chuzenji (Tzujenji), Shimotsuke, altitude 4,100 feet, June 22, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 2 broken females.

*Limnophila* (*Prionolabis*) *inermis* is allied to the three other members of the *lipophleps* group occurring in the Japanese Empire, differing decisively in the structure of the male hypopygium, especially the unarmed outer dististyle and the conformation of the gonapophyses.

**LIMNOPHILA (TRICHOLIMNOPHILA) PRIONOLABOIDES** sp. nov. Plate 1, fig. 15; Plate 3, fig. 36.

General coloration of thorax gray, the præscutum with three polished black stripes; fore femora with outer half blackened; abdomen, including hypopygium, black; male hypopygium with median notch of tergite relatively narrow, the lateral lobes broad, more or less bilobed by the presence of a lateral flange.

*Male.*—Length, 6 to 6.5 millimeters; wing, 7 to 8.

*Female.*—Length, about 7.5 millimeters; wing, 8.5.

Rostrum and palpi black. Antennæ (male) relatively long, if bent backward extending to mid-distance between the roots of the halteres and wings; scape brownish black; pedicel and flagellum brown, the outer flagellar segments passing into dark brown. Head light gray.

Pronotum dark gray. Mesonotal præscutum brownish gray, the usual three stripes highly polished, black, including the entire area of the stripe, not merely the cephalic portion, as in *pilifer;* scutum opaque brownish gray; scutellum clearer gray; mediotergite gray. Pleura dark gray. Halteres pale yellow. Legs with the fore coxæ darkened, the remaining coxæ yellow, a little infuscated at bases; trochanters yellow; femora yellow, the tips broadly blackened, most extensively so on the forelegs where fully the outer half is included; on middle and hind legs including about the outer fifth or sixth; tibiæ obscure yellow, the tips narrowly brownish black; basitarsi pale brown, the outer half and remainder of tarsi black. Wings (Plate 1, fig. 15) brownish yellow, the prearcular region clear light yellow; a restricted brown pattern, distributed as follows: Stigma, origin of Rs, cord, and outer end of cell 1st $M_2$; veins brown, yellow in the luteous prearcular region. Macrotrichia in outer ends of cells $R_2$ to $M_4$, inclusive. Venation: m-cu at or before mid-length of cell 1st $M_2$.

Abdominal tergites brownish black; sternites somewhat paler brown; hypopygium black. Male hypopygium (Plate 3, fig. 36) with the median region of tergite, 9*t*, somewhat produced, the lobes broad, each with a conspicuous lateral shoulder or flange; median notch relatively deep and narrow, the caudal end a little narrowed.

*Habitat.*—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Allotopotype, female. Paratopotypes, 3 males.

The nearest ally is undoubtedly *Limnophila* (*Tricholimnophila*) *pilifer* Alexander, which has the præscutal stripes pruinose excepting the cephalic ends of the intermediate pair, which are polished black. The latter species differs further in the reddish brown hypopygium, narrowly darkened fore femora, and the details of the hypopygium, as the very broad and relatively shallow tergal notch. The polished black præscutal stripes of the present fly produce a marked superficial resemblance to

certain small species of the subgenus *Prionolabis,* as *L.* (*P.*) *odai* Alexander.

ELEPHANTOMYIA (ELEPHANTOMYODES) MACKERRASI sp. nov. Plate 1, fig. 16.

Size large (wing, male, over 10 millimeters); mesothorax orange-yellow, immaculate; head brownish yellow; tarsi extensively snowy white; wings with a faint brown tinge; cells C and Sc dark brown; narrow but conspicuous brown seams at origin of Rs, along cord and outer end of cell 1st $M_2$; subterminal abdominal segments black.

*Male.*—Length, excluding rostrum, about 11 to 11.5 millimeters; wing, 10.8 to 11; rostrum, 6.5 to 6.7.

Rostrum black. Antennæ black, the basal portion of scape paler. Head obscure brownish yellow; anterior vertex at narrowest point about one-half wider than scape.

Mesonotum and pleura yellow or orange-yellow, immaculate. Halteres pale, the knobs dark brown. Legs with the coxæ yellow; trochanters yellowish testaceous; femora black, the bases restrictedly obscure yellow; tibiæ black; basitarsi black, the tips narrowly snowy white; segments two and three white, the remaining tarsal segments black. Wings (Plate 1, fig. 16) with a faint brownish tinge, patterned with dark brown, including all of cells C and Sc, stigma, and cell $R_2$ beyond it; relatively broad and conspicuous brown seams at origin and fork of Rs, along cord and outer end of cell 1st $M_2$; veins brownish black. Venation: Rs square at origin; m-cu nearly its own length beyond fork of M; cell 2d A of moderate length and width.

Basal abdominal tergites weakly bicolorous, obscure yellow basally, the outer one-half or more passing into dark brown; seventh and eighth segments uniformly blackened; hypopygium brownish black.

*Habitat.*—Java.

Holotype, male, Mount Malabar, altitude about 4,000 feet, May 26, 1929 (*I. M. Mackerras*). Paratopotype, male.

I take great pleasure in naming this conspicuous *Elephantomyia* after the collector, my friend Dr. Ian M. Mackerras. Compared with the thirteen other species of the subgenus *Elephantomyodes* described to date, the present fly is generally similar to *E.* (*E.*) *aurantia* (Brunetti), of British India, and *E.* (*E.*) *fuscomarginata* Enderlein, of Sumatra, by the combination of white tarsi and yellowish head. It differs from these and all other Malayan species with white tarsi in the conspicuously patterned wings. Members of the subgenus are now known

from as far east as New Britain and on the Australian mainland to northern New South Wales.

### ERIOPTERINI

### Genus LECTERIA Osten Sacken

*Lecteria* OSTEN SACKEN, Berliner Ent. Zeitschr. 31 (1887) 206.

#### Subgenus NEOLECTERIA novum

Characters as in typical *Lecteria*, differing only in the lack of cell $M_1$ of the wings.

*Type of subgenus.*—*Lecteria bipunctata* Edwards (Oriental Region: Borneo).[5]

As hitherto constituted, *Lecteria* includes besides the genotype, *armillaris* (Fabricius), of the Neotropics, about fifteen African species that have been discussed by the writer in another report.[6] The Bornean fly differs from all other described members of the genus in the loss of cell $M_1$ of the wings, a character that appears to me to be of considerable importance in the hexatomoid Eriopterini.

Moreover, it is apparent that *Psaronius* Enderlein, with several species in the Neotropics, cannot be maintained as a genus separate from *Lecteria,* despite the presence of tibial spurs. All known species of *Psaronius* have cell $M_1$ present, as in typical *Lecteria.* These three subgeneric groups may be separated as follows:

1. Wings with cell $M_1$ present.
   Wings with cell $M_1$ lacking (Oriental) .................. *Neolecteria* subgen. nov.
2. Tibial spurs present (Neotropical) .............................. *Psaronius* Enderlein.
   Tibial spurs lacking (Ethiopian, Neotropical) ...... *Lecteria* Osten Sacken.

#### GONOMYIA (GONOMYIA) OBSCURICLAVA sp. nov. Plate 1, fig. 17.

Belongs to the *cognatella* group; general coloration of notum dark brown; pleura light brown, with a broad ventral whitish stripe; rostrum black; halteres pale, the knobs infuscated; legs brownish black; wings with a strong brown tinge; stigma and a seam along cord brownish; m-cu shortly beyond fork of M; caudal margins of abdominal segments pale.

*Female.*—Length, about 3.5 millimeters; wings, 4.2.

Rostrum and palpi black. Antennæ with the scape reddish brown; pedicel blackish; first flagellar segment pale, remainder

[5] Sarawak Mus. Journ. 3 (1926) 265–266, pl. 9, fig. 10.

[6] Revue Zoologique Africaine 11 (1923) 375–381.

of flagellum black; antennæ (female) relatively long for a member of this genus; flagellar segments subcylindrical. Head with vertex pale.

Mesonotum dark brown, the anterior lateral pretergites white; posterior border of scutellum somewhat paler, obscure yellow. Pleura light brown, with a broad ventral whitish stripe, extending longitudinally from the fore coxæ to the base of the abdomen. Halteres pale, the knobs infuscated. Legs with the fore coxæ white, the remainder more yellowish testaceous; trochanters obscure yellow; remainder of legs brownish black. Wings (Plate 1, fig. 17) with a strong brown tinge, cells C and Sc somewhat clearer; stigma brown, oval, clearly defined; a distinct brownish suffusion along the cord; veins pale brown, darker along cord. Venation: Distance on costa between tips of $R_{1+2}$ and $R_3$ equal to nearly two-thirds the total length of vein $R_3$; m-cu shortly beyond fork of M.

Abdomen dark brown, the caudal borders of the segments pale, a little more expanded at lateral angles of tergites.

*Habitat.*—Sumatra.

Holotype, female, Fort de Kock, altitude 3,000 feet, 1926 (*E. Jacobson*).

The only species of the *cognatella* group so far described from eastern Asia are *Gonomyia* (*Gonomyia*) *aperta* Brunetti (British India) and *G.* (*G.*) *subcognatella* Alexander (western China). The present fly differs most evidently in the combination of darkened knobs of halteres, the faint but distinct brown seam along cord of wings, the brownish black legs, and other characters.

GONOMYIA (LIPOPHLEPS) JACOBSONIANA sp. nov. Plate 1, fig. 18; Plate 3, fig. 37.

General coloration of thoracic notum dark brown, the posterior border of scutellum broadly pale yellow; pleura black, with a narrow white longitudinal stripe; femora brownish yellow, fore and middle femora with conspicuous black tips, posterior femora with a subterminal black ring; bases of all tibiæ narrowly blackened; veins almost uniformly grayish subhyaline; stigma very pale; $Sc_1$ ending immediately before origin of Rs; caudal borders of abdominal tergites (male) pale; male hypopygium with three dististyles, all simple.

*Male.*—Length, about 2.8 to 3 millimeters; wing, 3.5 to 3.7.

*Female.*—Length, about 3.5 to 4 millimeters; wing, 3.8 to 4.

Rostrum and palpi black. Antennæ black, the basal two segments restrictedly yellow beneath; flagellar verticils (male) very long. Head chiefly white, the center of the posterior vertex darkened.

Anterior lateral pretergites restrictedly china-white. Mesonotal præscutum almost uniformly dark brown; pseudosutural foveæ black, conspicuous; posterior sclerites of notum brownish black, the posterior border of scutellum broadly pale yellow; mediotergite more or less pruinose. Pleura black, with a narrow white longitudinal line from base of fore coxæ across dorsal sternopleurite and dorsal meral region to base of abdomen; pteropleurite and cephalic portion of pleurotergite much paler, more orange-yellow. Halteres pale, the knobs dark brown, narrowly lined with whitish. Legs with the coxæ chiefly dark, excepting the fore coxæ, as described; trochanters obscure yellow; femora brownish yellow; fore and middle femora with broad and conspicuous apical black rings, the posterior femora with nearly as wide but distinctly subterminal rings; all tibiæ brownish yellow, the bases narrowly, the tips somewhat more broadly blackened; basitarsi brown basally, the tips and remaining tarsal segments black. Wings (Plate 1, fig. 18) relatively broad, almost uniformly grayish subhyaline; stigma very pale and scarcely indicated; costal region not variegated; veins pale brown, a little darker along cord. Venation: $Sc_1$ ending just before origin of Rs, $Sc_2$ at tip; basal section of $R_5$ elongate, about one-half r-m; m-cu shortly before fork of M.

Abdomen dark brown, in male the caudal borders of the tergites conspicuously china-white; sternites more uniformly darkened, paler medially but without pale apical bands; hypopygium yellowish brown. In female, tergites more uniformly darkened or with the pale caudal borders restricted. Male hypopygium (Plate 3, fig. 37) with three dististyles, all simple rods; innermost style, *id*, jointed at base and here with a group of four or five strong setæ, at near three-fourths the length of style with a further group of about four conspicuous setæ; intermediate style unusually slender but nearly equal in length to the outer; outer style, *od*, broad basally, the inner margin of outer third with a flange.

*Habitat.*—Sumatra, Mindanao.

Holotype, male, Fort de Kock, Sumatra, altitude 3,000 feet, 1926 (*E. Jacobson*). Allotopotype, female. Paratopotypes, 8 of both sexes; paratypes, several of both sexes, Madaum River,

Tagum, Davao district, Mindanao, at trap lantern, March 26 to 27, 1931 (*C. F. Clagg*).

I take unusual pleasure in naming this interesting *Gonomyia* after my old friend Mr. Edward Jacobson, distinguished student of the animal life of the Dutch East Indian islands. By Edwards's key to the Malayan species of *Lipophleps* [7] the present fly runs to *Gonomyia* (*Lipophleps*) *diffusa* (de Meijere), a species that is quite distinct in the pale brown subterminal rings on femora and the somewhat patterned, slightly infumed wings. I have not yet seen a male that can be definitely assigned to *diffusa*, which was described only from females. The present fly is amply distinct from all species of the subgenus so far described from Formosa and the Philippines.

**GONOMYIA (LIPOPHLEPS) ACUSPINOSA** sp. nov. Plate 3, fig. 38.

*Male.*—Length, about 3 millimeters; wing, 3.5.

Generally similar and closely allied to *G.* (*L.*) *jacobsoniana* sp. nov., differing in slight details of coloration and notable differences in the structure of the male hypopygium.

Antennæ dark throughout. Femora darker, the blackened tips on all legs terminal, preceded by a narrow, clearer yellow ring. Abdominal tergites uniformly darkened. Male hypopygium (Plate 3, fig. 38) with three dististyles; inner style, *id*, shortest, terminating in two acute spines, the outermost from a long basal tubercle that extends about to the level of the tip of inner spine, the actual spine short; inner spine long and slender, appressed to the outer one; mesal face of style at base, with a group of about nine or ten setæ surrounding a larger, more fasciculate one. Intermediate style, *md*, subequal in length to the outer, with almost the entire inner edge provided with a dense fringe of coarse appressed setulæ, these more protuberant and evident near base and at apex of style. Outer style, *od*, a simple, gently arcuated rod, shaped more or less like a slender boomerang. Phallosome, *p*, with the divergent arms terminating in acute blackened points, before tip a little expanded and microscopically setulose.

*Habitat.*—Sumatra.

Holotype, male, Fort de Kock, altitude 3,000 feet, 1926 (*E. Jacobson*).

A third species of the group is *Gonomyia* (*Lipophleps*) *alboannulata* Alexander (Philippines), which differs from the present

[7] Journ. Fed. Malay States Mus. 14 (1928) 104–105.

fly in the structure of the two inner styles of the male hypopygium, the innermost being trispinous, the middle style with the setulæ confined to the somewhat enlarged distal half or less.

**ERIOPTERA (TELENEURA) PERORNATA** sp. nov. Plate 1, fig. 19; Plate 3, fig. 39.

General coloration of head, pronotum, and mesonotum pale brownish yellow, the thoracic pleura chiefly darkened; legs yellow, the femora with vague indications of a narrow, slightly darker subterminal ring; wings yellowish cream color, with a heavy pattern of brown spots and clouds; $Sc_2$ opposite two-thirds Rs; male hypopygium with a single dististyle; gonapophyses and ædeagus powerfully developed.

*Male.*—Length, about 3.3 millimeters; wing, 4.

Rostrum and palpi black. Antennæ with basal segments black, the flagellum brownish black, with slender segments and conspicuous verticils. Head brownish yellow.

Pronotum and mesonotum light brownish yellow, the mediotergite blackened; a narrow lateral dark line on præscutum, extending from behind the pseudosutural foveæ to beyond the wing root. Pleura more or less distinctly striped longitudinally with dark brown and obscure brownish yellow, the latter color including the dorsopleural region and a more ventral stripe ending at the halteres. Halteres pale, the knobs weakly darkened. Legs with the coxæ dark; trochanters brown, their apices paler; remainder of legs pale yellow, the femora with vague indications of a narrow, scarcely darker, subterminal ring (only the forelegs remain). Wings (Plate 1, fig. 19) yellowish cream color, handsomely variegated by dark brown spots and clouds, including areas at h, origin of Rs, $Sc_2$, tip of $Sc_1$, cord, stigmal region, a nearly continuous band along vein $R_5$; a cloud at fork of $M_{3+4}$; marginal clouds at ends of all longitudinal veins excepting $R_5$; conspicuous paler brown clouds in bases of cells M to 2d A, in the latter cells including all but the outer ends and a narrow white seam the entire length of vein 1st A; veins yellow, darker in the clouded areas. Venation: $Sc_2$ ending opposite two-thirds the length of Rs; vein 2d A rather strongly sinuous.

Abdomen brownish black, the hypopygium more yellowish. Male hypopygium (Plate 3, fig. 39) with the tergite, *9t*, at apex produced into two lateral fleshy lobes provided with long coarse setæ. Basistyle, *b*, with a single developed dististyle, this appearing as a strongly curved horn-colored hook, narrowed to the slightly dusky tip that terminates in a small seta. Phallo-

some, *p*, conspicuous, the apparent gonapophyses appearing as long flattened blades that are longer than the dististyle; the ædeagus is a compressed blade, on margin with a long slender extension whose limits cannot be accurately determined in the unique type.

*Habitat.*—China (Szechwan).

Holotype, male, Mount Omei, on mossy cliffs in river gorge, altitude 3,600 feet, July 27, 1932 (*G. M. Franck*).

The most similar described species is *Erioptera* (*Teleneura*) *nigribasis* Edwards (Malayan Subregion), which is readily distinguished by the coloration of the legs, especially the blackened femoral bases; the wing pattern, with the details quite different from the present fly, although the general plan is the same; and especially the structure of the male hypopygium, which in *nigribasis* has two dististyles and the phallosome of entirely different construction. A careful examination of the unique type of the present species has failed to reveal any trace of the outer dististyle, or of its former position if lost by breakage.

**ERIOPTERA (ERIOPTERA) FUSCOHALTERATA Alexander.**

*Erioptera fuscohalterata* ALEXANDER, Proc. U. S. Nat. Mus. **68** art. 4 (1925) 11–12, fig. 3.

Described from a single broken male, Amagu Village, Ussuri, July, 1923 (*Cockerell*). An additional male in the Russian Academy of Sciences, taken at Nikolajevsk, on Amur River, Ussuri, June 23, 1914 (*Bjeloussov*).

The species is allied to the European *Erioptera* (*Erioptera*) *fuscipennis* Meigen or *E.* (*E.*) *lutea* Meigen, but is quite distinct in the structure of the male hypopygium, especially the slender, gradually narrowed, outer dististyles.

**ORMOSIA RECTANGULARIS sp. nov. Plate 1, fig. 20; Plate 3, fig. 40.**

General coloration light gray; antennæ short; halteres pale yellow; wings pale yellowish white, the prearcular and costal regions clear light yellow; a restricted brown pattern on wings; $R_2$ at fork of $R_3$ and $R_4$; m rectangular and spurred at union with outer section of $M_3$; anal veins divergent; male hypopygium without a spinous apical spur on basistyle; gonapophyses appearing as long yellow rods, their bases dilated.

*Male.*—Length, about 4.5 millimeters; wing, 5.

*Female.*—Length, about 5.5 millimeters; wing, 6.

Rostrum and palpi dark brown. Antennæ short; basal segments pale brown, the flagellum darker brown; flagellar segments oval, decreasing in size outwardly. Head gray.

Mesonotum light gray, the præscutum without clearly indicated stripes; pseudosutural foveæ and tuberculate pits black. Pleura clear gray throughout. Halteres pale yellow. Legs with the coxæ pale, sparsely pruinose, especially the fore coxæ; trochanters yellow; femora obscure yellow, the tips conspicuously brownish black; tibiæ light brown, the tips darker; tarsi brownish black. Wings (Plate 1, fig. 20) pale yellowish white, the prearcular and costal regions clearer yellow; a restricted brown pattern, including the stigma, seams along cord, m, and vein Cu; poorly indicated markings at ends of outer radial veins and in axillary region; veins brown, darker in the clouded areas, pale yellow in the luteous regions. Venation: $R_2$ at fork of $R_{3+4}$; veins $R_3$ and $R_4$ deflected cephalad at margin, the former more strongly so; cell 1st $M_2$ open, m rectangular and spurred at union with outer section of $M_3$; anal veins diverging.

Abdomen, including hypopygium, dark brown. Male hypopygium (Plate 3, fig. 40) with the basistyle, *b*, not produced at apex. Dististyles small, the inner, *id*, broad, narrowed into an apical point. Gonapophyses, *g*, appearing as long straight yellow rods, their bases dilated.

*Habitat.*—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Allotopotype, a broken female.

In the venation of the outer radial and medial fields of the wing, the present fly agrees with a group of Japanese and Formosan species, such as *Ormosia aculeata* Alexander, *O. anthracopoda* Alexander, *O. horiana* Alexander, and *O. laevistyla* Alexander, all of which differ in the apically convergent anal veins and in the terminal spine of the basistyle of the male hypopygium.

**MOLOPHILUS TRIACANTHUS** sp. nov. Plate 1, fig. 21; Plate 3, fig. 41.

Belongs to the *gracilis* group and subgroup; general coloration brownish gray, the humeral region of præscutum obscure yellow; halteres yellow; wings broad; male hypopygium without spinous lobes on basistyle; both dististyles simple, the outer one on distal half with a fringe of conspicuous black setæ; phallosome with three slender black spines.

*Male.*—Length, about 4 to 4.2 millimeters; wing, 5.3 to 5.5.

Rostrum and palpi brown. Antennæ relatively short, dark brown throughout. Head gray.

Anterior lateral pretergites pale yellow. Mesonotal præscutum and scutum dark grayish brown, the humeral region ob-

scure yellow; pseudosutural foveæ elongate, conspicuous; posterior border of scutellum obscure yellow; mediotergite dark gray. Pleura brownish gray. Halteres pale. Legs with coxæ and trochanters yellow; femora brownish black, the bases pale, more extensively so on posterior legs; tibiæ pale brown, the tips narrowly darker; tarsi brownish black. Wings (Plate 1, fig. 21) broad, faintly tinged with brown, the basal portions more yellowish; veins very pale brown, the prearcular and subcostal veins more yellow; macrotrichia brown, the costal fringe long and dense. Venation: Vein 2d A ending about opposite one-third the length of the petiole of cell $M_3$.

Abdomen brownish gray, the hypopygium somewhat more brightened. Male hypopygium (Plate 3, fig. 41) with the apical lobes of the basistyle all short and blunt, the mesal lobe small and darkened. Outer dististyle, *od,* a simple arcuated rod, the inner margin on distal half densely fringed with long black setæ. Inner dististyle, *id,* subequal in length to outer, the basal two-thirds flattened, the outer third narrowed and curved into an acute point, the surface with microscopic setulæ. Phallosome, *p,* with three slender, acute spines, one apical, the others lateral.

*Habitat.*—Japan (Honshiu).

Holotype, male, Yumoto, Shimotsuke, altitude 4,850 feet, June 20, 1932 (*S. Issiki*). Paratopotype, male.

*Molophilus triacanthus* is readily told from the other Japanese species by the large size, broad wings, and, especially, the structure of the male hypopygium. The trispinous phallosome is different from that of any other described species in eastern Asia.

**MOLOPHILUS CRASSULUS** sp. nov. Plate 1, fig. 22; Plate 3, fig. 42.

Belongs to the *gracilis* group and subgroup; general coloration brown; antennæ short; halteres darkened; wings with $Sc_1$ ending just beyond $R_2$; 2d A relatively short, ending opposite the caudal end of m-cu; male hypopygium with lobes of basistyle poorly developed; inner dististyle slender, at apex a little expanded into a slightly swollen bispinous head.

*Male.*—Length, about 3 millimeters; wing, 3.5.

Rostrum pale; palpi dark brown. Antennæ short; basal segments obscure yellow; flagellar segments dark brown. Head brownish testaceous.

Mesonotum medium brown, without clearly defined markings, the humeral region of præscutum obscure yellow. Pleura chiefly darkened, the ventral portions paler. Halteres darkened. Legs

with the coxæ and trochanters yellow; remainder of legs brown, the outer tarsal segments darker. Wings (Plate 1, fig. 22) grayish yellow, the costal and prearcular regions clearer yellow; veins pale brown, the macrotrichia dark brown; costal fringe unusually long and dense. Venation: $Sc_1$ ending just beyond $R_2$, the latter about in alignment with r-m; vein 2d A relatively short, ending opposite the caudal end of m-cu.

Abdomen dark brown, the hypopygium brighter. Male hypopygium (Plate 3, fig. 42) with the dorsal and mesal lobes of basistyle scarcely developed; ventral lobe, *vb*, produced as a broadly flattened extension that is divided into two parts by a linear slit. Outer dististyle, *od*, a flattened pale blade, the distal third narrowed into an acute black spine. Inner dististyle, *id*, nearly as long but slenderer and nearly straight, the head dilated and darkened, terminating in an apical point and with a small black marginal spur at the base of the head.

*Habitat.*—China (Szechwan).

Holotype, male, Mount Omei, altitude 4,800 feet, July 4, 1932 (*Franck*). Paratopotype, a broken male. Allotype, female, altitude 4,200 feet, June 29, 1932. Paratypes, 6 of both sexes, altitude 4,200 feet, June 29 to July 2, 1932; 4,800 feet, July 4, 1932.

There is no very near ally of the present fly among the described regional species. The structure of the male hypopygium is distinctive.

**MOLOPHILUS BARDUS** sp. nov. Plate 1, fig. 23; Plate 3, fig. 43.

Belongs to the *gracilis* group and subgroup; closely allied to *costalis;* male hypopygium with the dorsal lobe of basistyle pale, not tipped with a blackened spine; both dististyles long and slender, blackened to their bases.

*Male.*—Length, about 3 millimeters; wing, 3.5.

Rostrum and palpi black. Antennæ with the basal segments pale, the outer segments darker. Head brownish yellow.

Mesonotum and pleura almost uniformly pale brown. Halteres pale. Legs with coxæ and trochanters pale; remainder of legs broken. Wings (Plate 1, fig. 23) with a grayish yellow tinge, the costal border clear light yellow; cells near wing base more darkened; veins pale, darker in the basal areas. Venation: $R_2$ and r-m about in transverse alignment.

Abdomen brown, the hypopygium brighter. Male hypopygium (Plate 3, fig. 43) much as in *costalis*, differing in the pale-tipped, more obtuse, dorsal lobe, *db*, of the basistyle and the slightly longer and slenderer, entirely blackened dististyles.

Outer dististyle, *od,* very long and slender, gradually narrowed into a long slender spine. Inner dististyle, *id,* a trifle shorter, broader on basal half, the outer half slenderer and sinuous, the outer margin with a few appressed teeth.

*Habitat.*—China (Szechwan).

Holotype, male, Mount Omei, on mossy cliffs in river gorge, altitude 3,600 feet, July 27, 1932 (*Franck*).

Although closely allied to *Molophilus costalis* Edwards (Formosa), the present species is readily distinguishable by the details of the male hypopygium.

### Genus TOXORHINA Loew

*Toxorhina* LOEW, Linnæa Entomol. 5 (1851) 400.

#### Subgenus EUTOXORHINA novum

Characters as in the typical subgenus, differing in the complete loss of vein and cell $M_3$, there being only two radial and two medial veins reaching the wing margin.

*Type of subgenus.*—*Toxorhina* (*Eutoxorhina*) *simplex* sp. nov. (Australasian Region: Fiji).

The present group shows the greatest reduction in longitudinal veins of wing of any known crane fly, there being but eight reaching the margin ($Sc_1$, $R_{1+2}$, $R_5$, $M_{1+2}$, $M_4$, $Cu_1$, 1st A, and 2d A). Other groups of Tipulidæ that show a notable reduction in number of veins (as *Limonia: Alexandria* Garrett, *Orimarga: Diotrepha* Osten Sacken, and *Hexatoma: Cladolipes* Loew) have an additional branch of R preserved and so have nine longitudinal veins attaining the margin.

The three known subgenera of *Toxorhina* may be separated as follows:

1. Wings with two branches of Rs ($R_3$ and $R_5$) reaching the margin (tropicopolitan) ........ *Ceratocheilus* Wesché.
   Wings with a single branch of Rs ($R_5$) reaching the margin........ 2.
2. Three medial veins ($M_{1+2}$, $M_3$, $M_4$) reaching the margin (almost cosmopolitan) ........ *Toxorhina* Loew.
   Two medial veins ($M_{1+2}$, $M_4$) reaching the margin (Australasian). *Eutoxorhina* subgen. nov.

**TOXORHINA (EUTOXORHINA) SIMPLEX** sp. nov. Plate 1, fig. 24.

The unique type has lost the head and most of the abdomen.

Mesonotum chiefly reddish brown, the pleura blackened. Halteres pale yellow, the knobs weakly infuscated. Femora black, with a darker brown, nearly terminal ring, the extreme tips pale; remainder of legs brown. Wings (Plate 1, fig. 24) with a strong brownish tinge, cells Cu, 1st A, and 2d A somewhat paler; a

delicate pale streak in cell M, crossing m-cu into extreme base of cell $M_4$; a darker brown cloud on r-m and basal section of $M_{1+2}$ veins dark brown, more yellowish in the costal region. Basal abdominal tergites brown, the corresponding sternites blackened; abdomen broken beyond the second segment.

*Habitat.*—Fiji.

Holotype, sex?, Coli-i-Siva, June 20, 1924 (*E. H. Bryan, Jr.*). Type in Bishop Museum, Honolulu.

# ILLUSTRATIONS

[Legend: *a*, Ædeagus; *b*, basistyle; *d*, dististyle; *db*, dorsal lobe of basistyle; *g*, gonapophysis; *i*, interbase; *id*, inner dististyle; *mb*, mesal lobe of basistyle; *md*, intermediate dististyle; *od*, outer dististyle; *p*, phallosome; *t*, tergite; *vb*, ventral lobe of basistyle; *vd*, ventral dististyle.]

## PLATE 1

FIG. 1. *Limonia* (*Geranomyia*) *unifilosa* sp. nov.; venation.
2. *Limonia* (*Geranomyia*) *baliana* sp. nov.; venation.
3. *Limonia* (*Geranomyia*) *vanikorensis* sp. nov.; venation.
4. *Limonia* (*Pseudoglochina*) *bryophila* sp. nov.; venation.
5. *Orimarga* (*Orimarga*) *nudivena* sp. nov.; venation.
6. *Orimarga* (*Orimarga*) *æquivena* sp. nov.; venation.
7. *Pedicia* (*Nasiternella*) *hokkaidensis* sp. nov.; venation.
8. *Dicranota* (*Rhaphidolabis*) *platymera* sp. nov.; venation.
9. *Pseudolimnophila mobilis* sp. nov.; venation.
10. *Pseudolimnophila yumotana* sp. nov.; venation.
11. *Pseudolimnophila erecta* sp. nov.; venation.
12. *Limnophila* (*Prionolabis*) *sôunkyana* sp. nov.; venation.
13. *Limnophila* (*Prionolabis*) *luteibasalis* sp. nov.; venation.
14. *Limnophila* (*Prionolabis*) *inermis* sp. nov.; venation.
15. *Limnophila* (*Tricholimnophila*) *prionolaboides* sp. nov.; venation.
16. *Elephantomyia* (*Elephantomyodes*) *mackerrasi* sp. nov.; venation.
17. *Gonomyia* (*Gonomyia*) *obscuriclava* sp. nov.; venation.
18. *Gonomyia* (*Lipophleps*) *jacobsoniana* sp. nov.; venation.
19. *Erioptera* (*Teleneura*) *perornata* sp. nov.; venation.
20. *Ormosia rectangularis* sp. nov.; venation.
21. *Molophilus triacanthus* sp. nov.; venation.
22. *Molophilus crassulus* sp. nov.; venation.
23. *Molophilus bardus* sp. nov.; venation.
24. *Toxorhina* (*Eutoxorhina*) *simplex* sp. nov.; venation.

## PLATE 2

FIG. 25. *Limonia* (*Geranomyia*) *unifilosa* sp. nov.; male hypopygium.
26. *Limonia* (*Geranomyia*) *baliana* sp. nov.; male hypopygium.
27. *Limonia* (*Pseudoglochina*) *bryophila* sp. nov.; male hypopygium.
28. *Orimarga* (*Orimarga*) *nudivena* sp. nov.; male hypopygium.
29. *Pedicia* (*Nasiternella*) *hokkaidensis* sp. nov.; male hypopygium.
30. *Dicranota* (*Rhaphidolabis*) *platymera* sp. nov.; male hypopygium.
31. *Pseudolimnophila mobilis* sp. nov.; male hypopygium.
32. *Pseudolimnophila yumotana* sp. nov.; male hypopygium.
33. *Limnophila* (*Prionolabis*) *sôunkyana* sp. nov.; male hypopygium.

PLATE 3

FIG. 34. *Limnophila* (*Prionolabis*) *luteibasalis* sp. nov.; male hypopygium.
35. *Limnophila* (*Prionolabis*) *inermis* sp. nov.; male hypopygium.
36. *Limnophila* (*Tricholimnophila*) *prionolaboides* sp. nov.; male hypopygium.
37. *Gonomyia* (*Lipophleps*) *jacobsoniana* sp. nov.; male hypopygium.
38. *Gonomyia* (*Lipophleps*) *acuspinosa* sp. nov.; male hypopygium.
39. *Erioptera* (*Teleneura*) *perornata* sp. nov.; male hypopygium.
40. *Ormosia rectangularis* sp. nov.; male hypopygium.
41. *Molophilus triacanthus* sp. nov.; male hypopygium.
42. *Molophilus crassulus* sp. nov.; male hypopygium.
43. *Molophilus bardus* sp. nov.; male hypopygium.

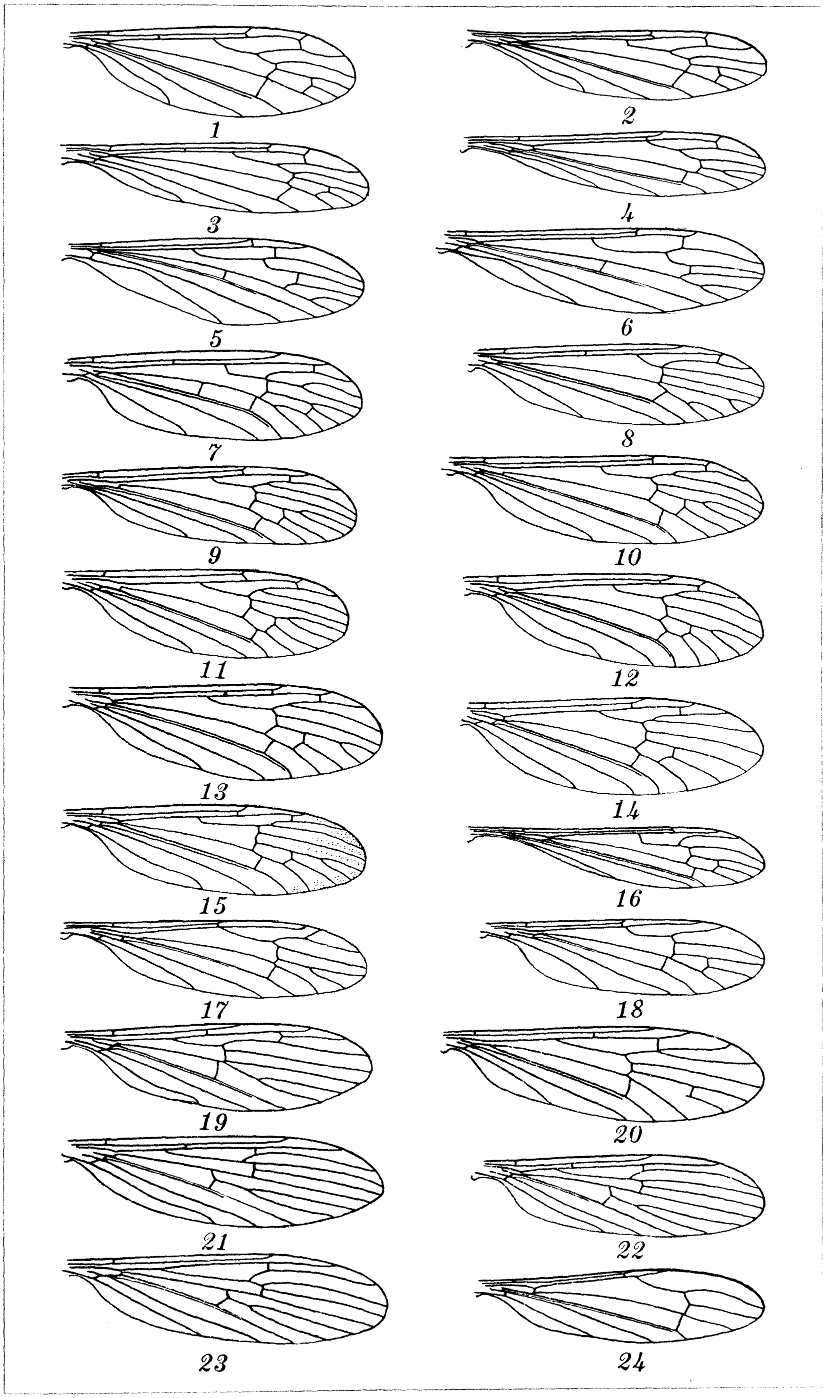


PLATE 1.

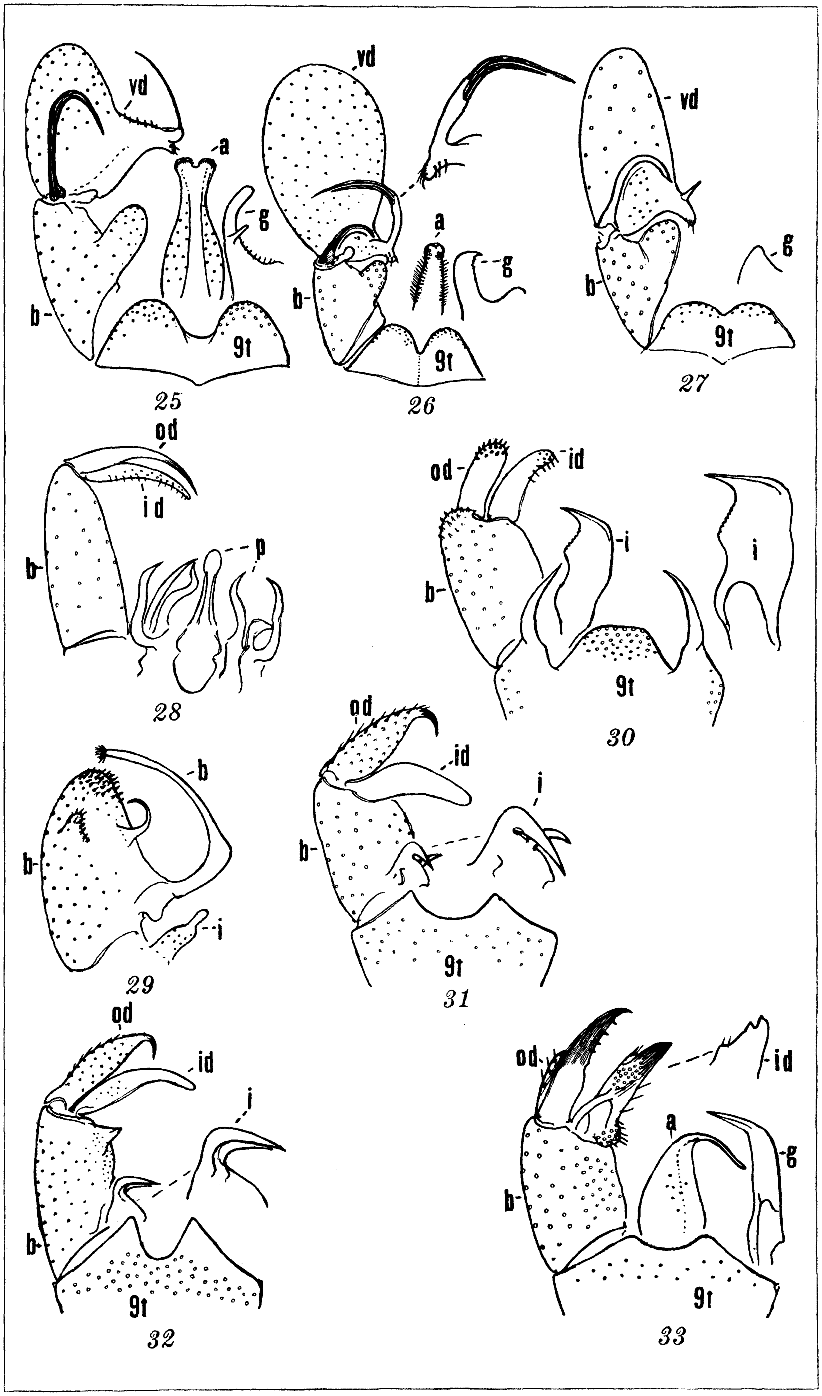
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PLATE 2.

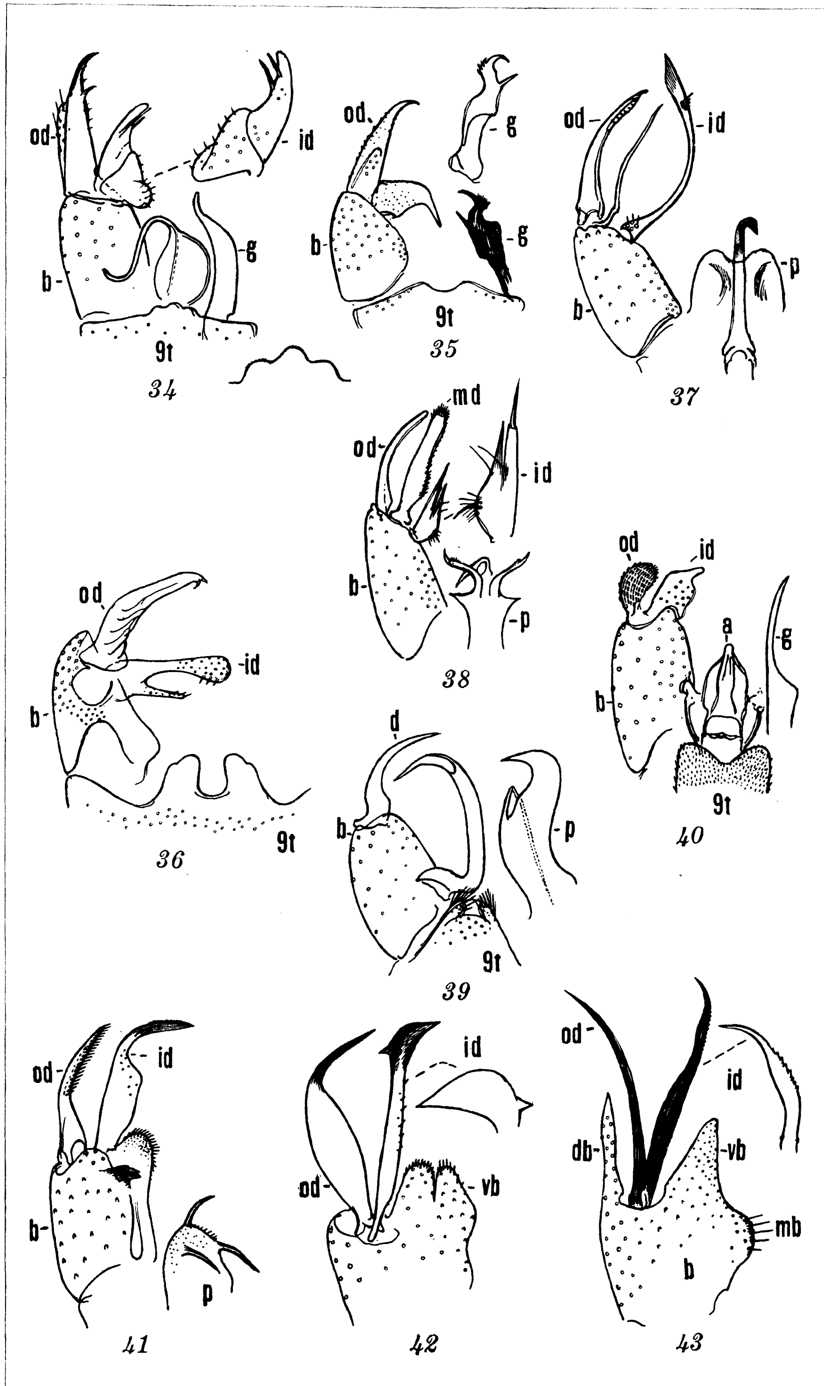
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PLATE 3.

# THE GENUS PEDICIA WITH SPECIAL REFERENCE TO THE JAPANESE SPECIES OF THE GENUS (DIPTERA: TIPULIDÆ)

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ONE PLATE

Since the genus *Pedicia* based on the European *Tipula rivosa* Linnæus was established by Latreille in 1809, ten species of the genus have been described from various parts of the world.

In the Japanese Empire, the genus *Pedicia* is represented by three known species; namely, *P. daimio* Matsumura, *P. brachycera* Alexander, and *P. subtransversa* Alexander. *Pedicia daimio* Matsumura was described from Hokkaido, as the type of the new genus *Daimiotipula*, the identity of which with *Pedicia* was later pointed out by C. P. Alexander. *Pedicia brachycera* Alexander and *P. subtransversa* Alexander were described from the materials taken in the "Japanese Alps," Honshu, by J. Machida.

In the course of my study of the Tipulidæ preserved in the Nawa Entomological Laboratory, Gifu, I found two male specimens belonging to this genus, which are evidently specifically distinct from each other and are apparently new to science. Fortunately, several specimens of one of these species have been collected on Mount Kinkwa, Gifu, by Mr. H. Ise and myself since that time. One male specimen from the Prefecture Iwate presented to me by Mr. T. Kato is also referable to this species. Another male specimen, taken at Hakone by Mr. H. Sawada, is slightly different from the specimens collected at Gifu, and may be treated as representing a subspecies. I have also examined material from Saghalien, through the courtesy of Dr. T. Uchida and Mr. I. Okada, and the species represented in this material seems to be identical with *P. cockerelli* Alexander from Siberia.

In the present paper two new species, one new subspecies, and one new to the fauna of the empire are described, and it may be safe to say that six species and one subspecies of the genus inhabit the Japanese Empire. Further, a description of the

genus, a list of the species hitherto known of the world, and a key to the Japanese species are also given.

I am very much indebted to Dr. J. Shibuya for his kind help in preparing the manuscript of this paper, and especially to Prof. Dr. T. Esaki and Prof. Dr. C. P. Alexander for their valuable suggestions for the present study. Further, I wish to express my hearty thanks to Mr. K. Yasumatsu for the trouble he took in preparing copies of some needed literature and drawings of certain species of *Pedicia;* and also to Dr. T. Uchida, Messrs. U. Nawa, M. Ishida, I. Okada, H. Sawada, N. Mori, T. Kato, and H. Ise for their kind coöperation in various ways.

## LIMONIINÆ

### PEDICIINI

### Genus PEDICIA Latreille

*Pedicia* LATREILLE, Gen. Crust. Ins. 4 (1809) 255.
*Daimiotipula* MATSUMURA, Thousand Ins. Japan, add. 2 (1916) 463.

Very near to *Tricyphona* Zetterstedt, but may be distinguished by much larger size and by the possession of the characteristic wing pattern of this genus.

Genotype.—*Tipula rivosa* (Linnæus).

Head small, somewhat roundish; vertex with a distinct tubercle; occiput extended caudad. Rostrum very short; palpi with the terminal segment usually greatly elongated. Antennæ rather short, 15- or 16-segmented; scape long and stout, cylindrical, bearing many bristles, chiefly on its dorsal part; pedicel long, cup-shaped, with many bristles; flagellar segments short and crowded, but several terminal segments usually somewhat elongated; first to eighth segments of the flagellum each bearing only a few long bristles, remaining terminal segments provided with the verticillate hairs which are elongated and conspicuous.

Wings with brown bands on the anterior margin, cord, and on vein Cu; these bands are connected with each other and make up the pattern characteristic of the genus. Wing venation closely allied to that of some species of *Tricyphona:* $Sc_2$ before or slightly beyond the origin of Rs; Rs usually ending in cell $R_{2+3}$, sometimes in alignment with petiole of cell $R_4$; cell $R_4$ shortly petiolate, rarely sessile; cord usually oblique; cell $M_1$ petiolate; cell 1st $M_2$ usually short and pentagonal. Basal part of Rs and two anal veins bearing no setæ, rarely very sparsely bristled.

Legs rather stout and hairy; tibial spurs conspicuous; claws simple.

Male hypopygium stout and hairy, upturned; basistyle with many strong bristles on its dorsoapical angle, the ventroapical angle produced into a shiny, acutely pointed horn, otherwise dististyle extremely terminal in position. Ovipositor with the apical third slightly curved upwards, the apex rather obtuse.

The species belonging to this genus are among the largest of the subfamily Limoniinæ and spread the wings even in repose. As far as I am concerned thirteen species and one subspecies are at present known to occur in the world, and all of them are restricted to the Holarctic Region.

*List of the species of the genus Pedicia.*

**1. PEDICIA RIVOSA Linnæus. Europe.**

*Tipula rivosa* LINNÆUS, Syst. Nat., ed. 10 (1758) 586.
*Limonia rivosa* MEIGEN, Klassif., Beschr. europ. zweifl. Ins. 1 (1804) 62, pl. 3, fig. 14.
*Pedicia rivosa* LATREILLE, Gen. Crust. Ins. 4 (1809) 255.
*Limnobia rivosa* MEIGEN, Syst. Beschr. europ. zweifl. Ins. 1 (1818) 118, 119, pl. 4, fig. 14.
*Pedicia rivosa* v. D. WULP, Diptera Neerland. 1 (1877) 487, 488, pl. 11, fig. 11.

**2. PEDICIA ALBIVITTA Walker. North America (Canada).**

WALKER, List Dipt. Brit. Mus. 1 (1848) 37.
ALDRICH, Psyche 7 No. 226 (1895) 201, 1 fig.
ALEXANDER, Cornell Univ. Agr. Exp. Sta., Memoir 25 (1919) 923, fig. 175.

**3. PEDICIA CONTERMINA Walker. North America (Canada).**

WALKER, List Dipt. Brit. Mus. 1 (1848) 38.
ALEXANDER, Cornell Univ. Agr. Exp. Sta., Memoir 25 (1919) 923, fig. 176.

**4. PEDICIA OBTUSA Osten Sacken. North America (California).**

OSTEN SACKEN, U. S. Geol. Geogr. Surv. 3 No. 2 (1877) 205, 206.
ALDRICH, Psyche 7 No. 226 (1895) 202.
OSTEN SACKEN, Psyche 7 No. 228 (1895) 229, 230.

**5. PEDICIA MAGNIFICA Hine. North America.**

HINE, Ohio Naturalist 3 (1903) 416, 417.

**6. PEDICIA DAIMIO Matsumura. Japan (Hokkaido).**

*Daimiotipula daimio* MATSUMURA, Thous. Ins. Japan, add. 2 (1916) 462, 463, pl. 25, fig. 5, female.
*Pedicia daimio* ALEXANDER, Philip. Journ. Sci. 24 (1924) 568, 569, male.
*Daimiotipula daimio* MATSUMURA, 6000 Illust. Ins. Japan-Empire (1931) 393, fig. 248.
*Pedicia daimio* ESAKI, Iconogr. Ins. Jap. (1932) 197, fig. 383.

7. **PEDICIA ARCTICA** Frey. Lapland (Ponoi).

FREY, Notulae Entomol. 1 No. 4 (1921) 110, 111, 4 figs.

8. **PEDICIA COCKERELLI** Alexander. Siberia (Olga), Japan (Saghalien).

ALEXANDER, Proc. U. S. Nat. Mus. 68 Art. 4 (1925) 9, 10, pl. 1, fig. 2.

9. **PEDICIA MARGARITA** Alexander. North America (Massachusetts).

ALEXANDER, Bull. Brooklyn Ent. Soc. 24 No. 5 (1929) 300–302, with a key for three species inhabiting northeastern North America.

10. **PEDICIA BRACHYCERA** Alexander. Japan (Honshu).

ALEXANDER, Philip. Journ. Sci. 50 (1933) 145, 146, pl. 1, fig. 12; pl. 3, fig. 40.

11. **PEDICIA SUBTRANSVERSA** Alexander. Japan (Honshu).

ALEXANDER, Philip. Journ. Sci. 50 (1933) 146, 147, pl. 1, fig. 13; pl. 3, fig. 41.

12. **PEDICIA NAWAI** Kariya, sp. nov. Japan (Honshu).

13. **PEDICIA GIFUENSIS** Kariya, sp. nov. Japan (Honshu).

13a. **PEDICIA GIFUENSIS SAWADAI** Kariya, subsp. nov. Japan (Honshu).

The Japanese species of *Pedicia* may be separated by the following key, chiefly based on the wing characters.

*Key to the Japanese species of the genus Pedicia.*

1. Brown seam along vein Cu prolonged to the wing margin .................... 2.
   Brown seam along vein Cu becoming obsolete before midlength of the vein and not reaching the margin .................... *brachycera* Alexander.
2. Cord oblique, cell 1st $M_2$ very short, pentagonal .................... 3.
   Cord subtransverse, cell 1st $M_2$ elongate, hexagonal .................... 4.
3. Brown spot at the origin of Rs not attaining to vein M .................... 5.
   Brown spot at the origin of Rs attaining or scarcely attaining to vein M .................... 6.
4. Antennæ uniformly yellowish brown .................... *cockerelli* Alexander.
   Antennæ with the scape and pedicel black .................... *subtransversa* Alexander.
5. Spot described above small and roundish; brown seam along vein Cu slightly dilated at wing margin; size small .................... *nawai* sp. nov.
   The spot not roundish; brown seam along vein Cu not dilated at wing margin; size large .................... *daimio* Matsumura.
6. Brown spot attaining to M; brown seam along vein Cu attached to vein 1st A at wing margin .................... *gifuensis* sp. nov.
   Brown spot scarcely attaining to M; brown seam along vein Cu not widened at wing margin .................... *gifuensis sawadai* subsp. nov.

**PEDICIA NAWAI** sp. nov. Plate 1, figs. 1 and 5.

Related to *daimio* Matsumura; size smaller; general coloration grayish yellow; dark markings on the wing narrow and pale, isolating a pale spot in cell $R_1$ as in *daimio*.

*Male.*—Length, about 17 mm; wing, 17.

Head, rostrum, and palpi blackish brown. Antennæ yellowish brown, basal two segments obscurely yellow; flagellar segments

tapering distad; several terminal segments with conspicuous verticils. Vertical tubercle distinct.

Thorax pinkish testaceous, gray pruinose. Præscutum with three dark brown stripes, the intermediate stripe feebly separated by a capillary pale line; lateral stripes extending as far as the scutal lobes across the suture; scutellum yellow; postnotum testaceous. Pleura testaceous, gray pruinose. Halteres pale yellow. Legs with the coxæ and trochanters yellowish brown; femora yellow, tips darkened; tibiæ and tarsi dark brown. Wings (fig. 1) of the usual *Pedicia*-pattern; the costal margin much paler than the remaining dark markings, the humeral region pale yellow; brown seam along vein Cu somewhat widened at the wing margin; a projecting spot at the origin of Rs roundish; cell $R_1$ with a pale spot at the root of the seam along the cord, as in *daimio*. Venation: Rs angulated and short-spurred at origin; petiole of cell $M_1$ nearly equal to m.

Abdomen yellowish brown, the caudal half fuscous; basal tergites with a median dark stripe. Male hypopygium (fig. 5) dark brown, dorsoapical angle of basistyle with a small group of yellow setæ. Dististyle (fig. 5, *d*) rather large and rectangular, with a small bladelike protuberance on ventral mesal face.

*Habitat.*—Japan (Honshu).

Holotype, male, Mount Ontake, Province Hida, April 16, 1897 (*Y. Nawa*), in the Nawa Entomological Laboratory, Gifu.

The present species is named in honor of the former director of the laboratory, the late Y. Nawa.

**PEDICIA GIFUENSIS** sp. nov. Plate 1, figs. 2, 6, 7, and 8.

Allied to *daimio* Matsumura; general coloration grayish ocherous; wings with the pattern broad and dark brown, with a pale spot in cell $R_1$.

*Male.*—Length, about 26 mm; wing, 24.

*Female.*—Length, 28 mm; wing, 23.

Rostrum, palpi, and head blackish brown. Antennæ dark yellowish brown, basal two segments fuscous. Female antennæ (fig. 7) similar to those of the male, apparently 15-segmented. The vertical tubercle with a circular depression.

Pronotum testaceous, dark brown medially; præscutum ocherous yellow, with three brown stripes, the intermediate one distinctly dark gray; lateral stripes crossing the suture onto scutum; scutellum yellow; postnotum rusty yellow, median spot tinged with gray. Pleura yellowish ocherous, white pruinose.

Halteres pale yellow. Legs with coxæ and trochanters testaceous; femora yellow, tips distinctly blackened, more broadly and conspicuously on the fore femora, more narrowly and abruptly on the hind femora; tibiæ and tarsi blackish brown. Wings (fig. 2) with the usual pattern of the genus; the pattern broader than in *daimio,* with a minute pale spot in cell $R_1$; humeral region pale yellow; the spot at origin of Rs attains to M; band along vein Cu touching vein 1st A at wing margin. Venation: Petiole of cell $M_1$ subequal to m.

Abdomen testaceous; tergites with a nearly continuous median brown stripe, sternites similar; terminal segments passing into dark brown. Male hypopygium (fig. 6) with basistyle stout; dorsoapical angle of basistyle produced into an obtuse jut that is less densely provided with yellow setæ. Dististyle (fig. 6, *d*) dark brown, heavily sclerotized, with a small projection on ventral mesal face, the ventral face sole-shaped, the apex shiny, provided with three or four minute spines. Ovipositor (fig. 8) with the tergal valves slightly upturned at the tip.

*Habitat.*—Japan (Honshu).

Holotype, male, Mount Kinkwa, Gifu, September 30, 1901 (*U. Nawa*).

Allotopotype, female, May 27, 1932 (*S. Kariya*).

Paratopotypes: 1 male, April 13, 1932 (*S. Kariya*); 2 males, April 29, 1932 (*S. Kariya*); 1 female, May 12, 1933 (*H. Ise*). Paratype, 1 male, Pref. Iwate, August 25, 1933 (*T. Kato*).

Two male paratopotypes from Mount Kinkwa are apparently devoid of the pale spot in cell $R_1$, but no other difference even of subspecific significance between these specimens and the holotype can be detected. Holotype in the Nawa Entomological Laboratory, Gifu; other specimens in my collection.

**PEDICIA GIFUENSIS SAWADAI subsp. nov.** Plate 1, fig. 3.

*Male.*—Length, 24 mm; wing, 21.

Similar to *P. gifuensis* in general, but differs from the latter as follows:

Size slightly smaller; wings (fig. 3) with the seams along vein Cu and the cord narrower, the former not widened at the wing margin; pale spot in cell $R_1$ larger; the spot at origin of Rs scarcely extending to M. Venation: Petiole of cell $M_1$ a little longer than m; cross vein m-cu just before the fork of M.

*Habitat.*—Japan (Honshu).

Holotype, male, Gora, Hakone, May 17, 1932 (*H. Sawada*), in my collection.

This subspecies is named in honor of Mr. H. Sawada, who has presented to me many interesting crane flies from Hakone.

**PEDICIA COCKERELLI Alexander. Plate 1, figs. 4 and 9.**

*Pedicia cockerelli* ALEXANDER, Proc. U. S. Nat. Mus. **68** Art. 4 (1925) 9, 10, pl. 1, fig. 2.

Holotype, a male, taken from Olga, Siberia.

Four males, Kashiho, Saghalien, July 10–11, 1933 (*T. Uchida* and *I. Okada*). These specimens agree well with Alexander's description except in the wing venation (fig. 4), which may apparently be very variable in this species. The species is distinct from the other Japanese species of *Pedicia* in the coloration of the body, unicolored antennæ, somewhat vague markings of the wings, and the structure of the male hypopygium (fig. 9). Although the species is closely allied to *P. rivosa* Linnæus (Europe), it differs from the latter in the coloration of the body, antennæ, and legs, as well as in the structure of the male hypopygium, especially in the details of the ventroapical horn of the basistyle (fig. 9, *h*) and the extended dististyle (fig. 9, *d*).

Three of the four specimens from Saghalien mentioned above are preserved in the Entomological Institute of the Hokkaido Imperial University, Sapporo, and one is in my collection.

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# ILLUSTRATION

### Plate 1

FIG. 1. *Pedicia nawai* sp. nov., wing.
2. *Pedicia gifuensis* sp. nov., wing.
3. *Pedicia gifuensis sawadai* subsp. nov., wing.
4. *Pedicia cockerelli* Alexander, wing.
5. *Pedicia nawai* sp. nov., male hypopygium, lateral aspect.
6. *Pedicia gifuensis* sp. nov., male hypopygium, lateral aspect.
7. *Pedicia gifuensis* sp. nov., female antenna.
8. *Pedicia gifuensis* sp. nov., ovipositor.
9. *Pedicia cockerelli* Alexander, male hypopygium, ventral aspect.

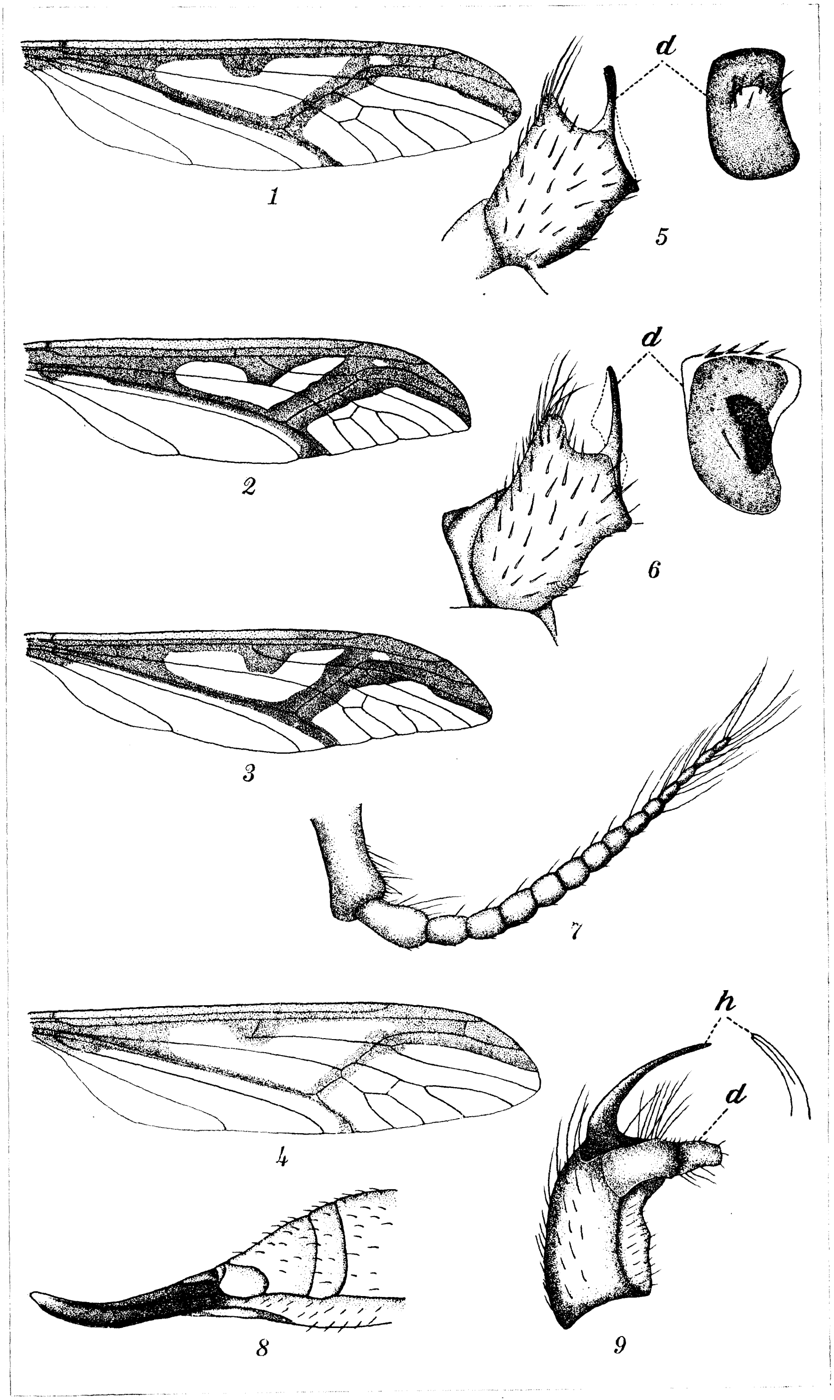


PLATE 1.

# THIRTEENTH CONTRIBUTION TO THE COLEOPTERA FAUNA OF THE PHILIPPINES

By W. SCHULTZE

*Of Bad Tölz, Germany*

TWO PLATES

In this paper I am reporting new species of Cerambycidæ and Curculionidæ from the Philippine Islands. Unless otherwise stated, the material was collected by A. de los Reyes and A. Duyag, who have previously been collecting for me. It again includes a number of pachyrrhynchids. On Plate 2 are given side views of the new species in schematic form, in the same relative size as in my monograph on pachyrrhynchids.[1] Through the figures the identifications in this group, which contains many species, are greatly facilitated. The types of all species described herein are represented in my collection. The following new species are described in this paper:

CERAMBYCIDÆ

*Pseudabryna hieroglyphica.*
*Cylindrepomus sexlineatus.*
*Niphonoclea ornata.*
*Proteuclea palawana.*
*Acronia luzonica.*
*Pseudodoliops schwarzeri.*

CURCULIONIDÆ

*Pachyrrhynchus monilifer stellulifer* var. *neojugifer.*
*Pachyrrhynchus rizali.*
*Pachyrrhynchus bucasanus ornatus.*
*Pachyrrhynchus galeraensis.*
*Pachyrrhynchus davaoensis.*
*Pachyrrhynchus regius* var. *boronganus.*
*Macrocyrtus trilineatus.*
*Apocyrtus chapmani.*
*Proapocyrtus luzonicus.*
*Metapocyrtus casiguranus.*
*Metapocyrtus herrei.*
*Metapocyrtus dibagonus.*
*Metapocyrtus prolongatus.*
*Metapocyrtus tumorosus.*
*Metapocyrtus mumunganus.*
*Metapocyrtus reyesi daconus.*
*Metapocyrtus iridanus.*
*Metapocyrtus subpilosus.*
*Metapocyrtus duyagi.*
*Metapocyrtus subspinipes.*
*Metapocyrtus multimaculatus.*
*Metapocyrtus tristis.*
*Metapocyrtus corpulentus.*
*Metapocyrtus perarmatus.*
*Metapocyrtus alabatanus.*
*Metapocyrtus breviarmatus.*
*Celebia samarana.*
*Coptorhynchus ornatus.*
*Alcides duyagi.*
*Alcides negrosensis.*
*Alcides subcuprinus.*
*Alcides lagunensis.*

[1] Philip. Journn. Sci. 23 (1923) 609–673, pls. 1–6; 24 (1924) 309–366, pls. 7–9; 25 (1924) 359–390, pls. 1–2; 26 (1925) 131–309, pls. 1–12.

## CERAMBYCIDÆ

**PSEUDABRYNA HIEROGLYPHICA** sp. nov. Plate 1, fig. 6.

Related to *P. luzonica* Schultze.[2] Glossy black with white tomentose markings. Head irregularly scattered-punctate, Front with a white longitudinal tomentose stripe extending to the vertex. The latter with a fine glistening longitudinal callosity medially. Prothorax somewhat broader than long, subcylindrical, glossy, remotely scattered-punctate. On the sides, next to the anterior margin, a narrow tomentose stripe, and over the anterior coxæ a spot. Elytra faintly glossy, in the basal third irregularly punctate, the punctation coarsest behind the humeral projections, and, gradually becoming finer, continuing on the dorsolateral slope of the elytra to the apical third. In the basal third of the elytra a crossbandlike combination of tomentose lines and stripes partly spotlike expanded. The bandlike markings united along the outer margins by a tomentose line; a tomentose stripe along the suture. Behind the middle of the elytra a further crossbandlike combination of two zigzag lines; from the middle to the apex a narrow sutural and lateral marginal stripe; and in the apical fourth of each elytron two small oblong spots. Femora with several oblong tomentose spots in the basal half. Second tarsal joints entirely and the claw joints partly white tomentose.

Length, 13.7 mm; shoulder breadth, 5.

LUZON, Nueva Vizcaya Province, Balete Pass (*W. Schultze*).

This species can readily be distinguished from *P. luzonica* Schultze by the bandlike zigzag markings.

**CYLINDREPOMUS SEXLINEATUS** sp. nov. Plate 1, fig. 3.

Head, antennæ, prothorax, legs, and underside light red-brown, elytra dark brown with pale yellowish tomentose stripes. Head with a fine sharp median groove extending from the anterior margin to the vertex. First antennal joint externally densely granulate. Prothorax cylindrical, longer than broad laterally, very shallow near the anterior margin, very strongly constricted near the posterior margin all around, and on either side on the constriction a round tomentose spot. Prothorax mesodorsally and on the sides minutely transversely furrowed. Scutellum semicircular, the margins slightly upturned. Elytra, with the exception of a narrow border along the suture and the apical part, densely and evenly punctate. Each elytron at the

[2] Philip. Journ. Sci. § D 11 (1916) 347.

apex markedly reduced and coming to a sharp point, which diverges from the point of the other elytron. On each elytron dorsally a longitudinal tomentose stripe, which extends from the base to before the middle, then, after a short interruption, continues to near the apical part, and finally, after another interruption, ends as a small spot before the pointed apex. A further, very much shortened, longitudinal stripe lateral and parallel to the first mentioned in the apical half of the elytra.

Length, 13.5 mm; shoulder breadth, 3.6.

MINDANAO, Lanao Province, Mumungan (*W. Schultze*).

**NIPHONOCLEA ORNATA sp. nov.** Plate 1, fig. 5.

Ground color red-brown, prothorax velvety black, each elytron with two small basal black tomentose spots and a large eyespot bordered with light brownish. Head scatteredly punctate, with a narrow, shining longitudinal callosity medially, light brownish tomentose; punctation partly concealed by the toment. The black tomentation of the prothorax on the posterior margin medially interrupted by a triangular light brownish spot, and blending laterally into the red-brown ground color. Elytra pronouncedly and fairly regularly punctate. Of the two basal black tomentose spots on each elytron, the dorsal one is oblong oval and the other compactly V-shaped, lying laterally behind the humeral hump near the lateral margin. The two spots are partly bordered by a light brown toment. Behind the middle a large roundish spot also bordered anteriorly and laterally by a light brownish band; the part of the elytra lying between this spot and the apex, red-brown tomentose, also the legs.

Length, 16.7 mm; shoulder breadth, 5.6.

SAMAR, Borongan.

This species is easily distinguishable from the others of the genus by its peculiar markings.

**PROTEUCLEA PALAWANA sp. nov.** Plate 1, fig. 7.

Black with white tomentose markings. Head intricately scattered-punctate, front of head and vertex faintly white tomentose, lateral margins of front and sides of head more pronounced tomentose. Front medially with a fine longitudinal callosity extending to the vertex. Fourth joint of antenna for three-fourths of its length white tomentose. Prothorax one-fourth broader than long, coarsely confused punctate, with a short compact thorn on either side next to the anterior margin. Toment extremely faint, only partially dense and forming small

white dots dorsally denser and appearing white laterally; a narrow white tomentose stripe along the posterior margin. Elytra pronouncedly and regularly remotely punctate, extremely faint; only the puncture margins more pronouncedly tomentose, and, irregularly scattered over the elytra, small round tomentose spots, which become more numerous in the apical part. On the lateral margin in the basal third a large oblong tomentose spot terminating in a triangular figure. Behind the middle of each elytron a transverse band spreading out in the form of a wedge to the lateral margin. Underside of pro-, meso-, and metathorax, as well as the abdominal segments lateral, white tomentose, the legs less markedly so.

Length, 13.8 mm; width, 4.6.

PALAWAN, Iwahig (*C. M. Weber*).

**ACRONIA LUZONICA** sp. nov. Plate 1, fig. 1.

Head, prothorax, and legs glossy black, elytra dull black with a faint and indistinct silver-gray transverse band. Front irregularly, coarsely scattered-punctate, the punctation finer and sparser toward the vertex. The latter with a faintly marked, longitudinal furrow medially. Next to the mandibular base several white toment hairs, and below the lower half of the eye an oblong white tomentose spot. A further small indistinct tomentose spot before the upper half of the eye. Antenna black, the first and third joints below and the fourth in the basal half white tomentose; third to the last joint near the apex sparsely beset with black setæ. Prothorax very glossy, lateral sparsely, scatteredly punctate, sides with a sharply marked anteromarginal groove. Laterally at the posterior margin a white tomentose stripe. Elytra irregularly scattered-punctate and very minutely black tomentose, except a poorly delimited fine light gray tomentose crossband medially. The anterior margin of the crossband is more sharply set off, the former on each elytron has a sickle-shaped white tomentose spot. On the outer margin of the elytra in the apical third a small triangular white tomentose spot. Apical margin also white tomentose. Anal segment with a mesal groove terminating in a triangular depression. The latter white tomentose, and on either side an oblong tomentose patch.

Length, 19 mm; shoulder breadth, 7.

LUZON, Cagayan Province, Peñablanca.

#### Genus PSEUDODOLIOPS novum

Very similar to the genus *Doliops* Waterh. Front of head without longitudinal grooves or callosity medially; eye kidney-shaped, surrounding the antennal base on three sides. First joint of the antenna moderately thickened, smooth, slightly conical, second joint very short; the two together somewhat shorter than the third joint and about as long as the fourth. Prothorax barrel-shaped, a third broader than long, the sides slightly bulging. Femora very pronouncedly club-shaped.

*Type.—Pseudodoliops schwarzeri* sp. nov.

**PSEUDODOLIOPS SCHWARZERI sp. nov. Plate 1, fig. 8.**

Black with white tomentose markings. Head with a tomentose stripe extending from the front to the vertex, sides also white tomentose. Anterior half of the third and fourth joints of the antenna gray-white tomentose. Prothorax finely and moderately densely black tomentose, with a groove parallel to the anterior margin and two grooves parallel to the posterior margin. The space between the anterior margin and the inner posterior margin pronouncedly scattered-punctate. Sides with a large, roundish, partly interrupted, white ringband. Scutellum white tomentose, elytra irregularly striate-punctate, punctuation next to the base coarse, dense and rasplike granulate. Each elytron in the basal third with a broader, somewhat curved, white transverse band extending from the lateral margin to near the suture, and with a narrower crossband in the apical third. Apical triangle with an irregular, oblong spot. Tibiæ in the apical half black setose, especially markedly so at the outer margin.

Length, 10 mm; shoulder breadth, 4.

MINDANAO, Zamboanga Province, Zamboanga.

I have named this species in honor of the recently deceased cerambycid specialist Herrn Bernh. Schwarzer, Schweinsheim.

## CURCULIONIDÆ

**PACHYRRHYNCHUS MONILIFER STELLULIFER [3] var. NEOJUGIFER var. nov.**

This variety strongly resembles *P. jugifer* Waterh., especially in the elytral markings. Ground coloring glossy blue-black. Scale markings pale greenish, cream-colored, or pale pink. Prothorax with an arrow-shaped longitudinal stripe on the disk

[3] Schultze, Philip. Journ. Sci. 23 (1923) 645, pl. 5, figs. 14 and 18.

extending forward two-thirds of its length from the base; on either side of the anterior margin a small crescent-shaped scale spot and on the sides over the anterior coxæ a longitudinal stripe. Elytra, with exception of the following bare spots, completely scaled. A large oval sutural spot in the basal half, and an oblong triangular sutural spot extending from behind the middle to the apex. Besides, in the apical half of each elytron a more or less markedly reduced triangular bare spot. The sutural spots are medially more or less connected with each other.

MINDORO, Puerto Galera, 3 specimens.

**PACHYRRHYNCHUS RIZALI** sp. nov. Plate 1, fig. 17.

Metallic, coppery red shining with pale green scale spots. Rostrum, the apical half swollen, the basal half with a shallow impression and a triangular scale spot cut in two by a fine mesal groove; a small scale swarm below the eyes. Prothorax subglobular, smooth, with a faint anteromarginal groove and a more pronounced posterior marginal groove. Dorsally in the middle, on the anterior margin and on the posterior margin, two triangular rounded scale spots, on either side medially between the anterior and posterior margins, a larger oval spot, and laterally above the fore coxæ a broader irregular scale stripe. Elytra with sharply pronounced striæ which become more pronounced laterad. Each elytron with eleven more or less oval or roundish spots forming three irregular transverse rows, as well as two sutural spots common to both elytra. The basal transverse row consists of three spots, of which the one lying between the second and third puncture rows is oblong-oval, the medial one is smallest and round, the third is large and elongate, lying some distance from the lateral margin. The second or medial transverse row consists of four spots of which three are roundish, the fourth spot, being the largest on the elytron, is elongate and located at the lateral margin. The third transverse row consists of three spots of which that lying near the suture is larger and oval. In the apical triangle is another, larger, triangular spot. Of the two sutural spots one is between the second and third transverse rows and the other next to the apex. Undersides of the prothorax and of the mesothorax scaled, the metathorax only laterally. Terminal abdominal segment smooth medially, depressed and rugose-punctate laterally, on either side with a scale spot. Femora with a spot ventrally next to the apex.

Male, length, 12.6 mm; width, 6.

Female, length, 12 mm; width, 6.

LUZON, Tayabas Province, Casiguran: Nueva Vizcaya Province, Mount Dibago.

This species is related to the species of my group VI[4]—namely, *P. multipunctatus* Waterh. *pseudoproteus* Schultze, and *elegans* Waterh., but may be distinguished from the latter especially by the peculiar markings of its prothorax. In the old specimens the ground color is black. I name this species in honor of the Philippine patriot José Rizal. Collected with *P. rizali* on the same bushes was a *Metapocyrtus* species which has a mimicry relationship to the former.

**PACHYRRHYNCHUS BUCASANUS[5] subsp. ORNATUS subsp. nov.**

Glossy dark green with pale yellow-green scale spots which are larger than those on the type species. Prothorax with spots as in the typical form, but without scale stripes at the anterior and posterior margins. Each elytron with eight to nine spots, in two specimens a third, very small spot between the two spots in the second transverse row. The third transverse row, which in each elytron of the typical form has four spots, consists, in the case of these three specimens (four are before me) of *ornatus* of only three spots.

SAMAR, Borongan.

Together with the above species was collected another species of the cerambycid genus *Doliops*, which stands in a mimicry relationship to *P. bucasanus ornatus*.

**PACHYRRHYNCHUS GALERAENSIS sp. nov.**

Related to *P. erichsoni* Waterh. Head, prothorax, and legs glossy metallic dark blue, elytra dully black, scale spots pale reddish pink. Rostrum in the apical half much swollen, depressed medially and from there to the front with a very pronounced medial groove, under the eye a scale spot. Prothorax subglobular, with a round scale spot mesally on either side and a very large spot above the fore coxæ. Elytra with pronounced puncture rows. Each elytron with eleven scale spots forming three transverse rows. The basal transverse row consists of three spots of which the mesal one is very small and round, the others are large and oblong oval; the mesal transverse row also consists of three spots, of which the medial one

[4] Philip. Journ. Sci. 24 (1924) 316.

[5] Deutsche Ent. Zeitschr. (1922) 40, pl. 1, fig. 11, female; Philip. Journ. Sci. 23 (1923) 665, pl. 2, fig. 1; pl. 5, fig. 10.

is the smallest; the third transverse row consists of four spots, the spot lying between the fourth and fifth puncture row being the smallest; in the apical triangle is another, larger, triangular spot. Meso- and metathorax each with a scale spot laterally.

Female, length, 13.7 mm; width, 6.6.

MINDORO, Puerto Galera.

**PACHYRRHYNCHUS DAVAOENSIS sp. nov.**

Related to *P. speciosus* Waterh. and *postpubescens* Schultze. Brightly shining metallic coppery with cream-colored scale markings. Rostrum with a triangular depression, front of head with a wedge-shaped scale spot. Prothorax smooth, with a longitudinal stripe on the disk, extending from the base to near the anterior margin, sides with a large ring-shaped scale spot. Elytra with fine but sharply marked puncture rows. Each elytron at the base with a large irregularly oval ring-shaped spot similar to that in *P. speciosus* Waterh.,[6] mesally with two subparallel transverse lines confluent, however, along the suture instead of crossing it as in *P. speciosus* and *postpubescens*. These two transverse lines are confluent also at the lateral margin and continuing circumscribe in the apical part of each elytron a triangular figure, again similar to that in *speciosus*. Underside of prothorax and of mesothorax also scaled, metathorax and first abdominal segment laterally with a scale spot. Femora each with a small scale spot below near the apex.

Male, length, 13,6 mm; width, 6.

MINDANAO, Davao Province, Apo Volcano, altitude 2,000 meters (*J. Clemens*).

**PACHYRRHYNCHUS REGIUS [7] var. BORONGANUS var. nov.**

On the prothorax, discally, the arrow-shaped marking of the type is very much broadened in this variation. The ring-shaped markings of the elytra are smaller, and the large basal ring spot in var. *boronganus* is oblong oval.

SAMAR, Borongan.

The note of Heller [8] is erroneous in so far as it concerns *P. regius* Schultze from Leyte Island; what is meant is probably the above variation from Samar Island.

[6] Philip. Journ. Sci. 23 (1923) 657, pl. 2, fig. 23.

[7] Philip. Journ. Sci. 21 (1922) 579, pl. 2, fig. 6, female; 23 (1923) 657, pl. 2, fig. 25; pl. 9, fig. 14.

[8] Wien. Ent. Zeitg. 41 (1924) 172.

**MACROCYRTUS (s. str.) TRILINEATUS sp. nov. Plate 1, fig. 2.**

Dark brown with pale green scale markings. Head, rostrum irregularly scattered-punctate with a shallow, flat impression and a fine medial groove, the punctation diminishing on the front, the latter with a few scattered scales. Prothorax finely and irregularly scattered-punctate, on the disk with an oblong not sharply delimited scale spot, on either side a broad longitudinal scale stripe which is interrupted before the middle, and over the fore coxæ an irregular scale spot. Elytra very minutely coriaceously rugose with indistinct puncture rows. Each elytron between the second and third rows with a longitudinal scale stripe extending from the base to the apex, medially this stripe is spotlike expanded by means of an oblong scale swarm. A further stripe, laterally, next to the lateral elytral slope, which, however, is interrupted, and forms in the basal half two large oblong spots, and in the apical half two small fragmentary spots. A further scale stripe at the lateral margin, interrupted mesally. Mesothorax and metathorax on either side with an irregular scale spot. Inner margin of the hind tibia armed with four blunt teeth.

Male, length, 16 mm; width, 6.3.

LUZON, Benguet Subprovince, Irisan (*W. Schultze*).

In general form this species resembles most *M. contractus* Chevr. (=*nigrans* Pasc.).

**APOCYRTUS CHAPMANI sp. nov. Plate 1, fig. 14, female.**

Black with light greenish or bluish scale spots. Rostrum minutely scattered-punctate, vaulted laterally, with a faintly marked mesolongitudinal groove divided from the front by a deep transverse groove. Front scatteredly punctate and scaled, with a sharply outlined mesal groove. Prothorax subglobular, very coarsely and evenly rounded-granulate at the anterior margin, delimited by an indistinct shallow constriction, smooth. Disk with a fine mesolongitudinal groove and narrow scale stripes. Prothorax laterally scatteredly scaled, but over the fore coxæ with a large spotlike scale swarm. Elytra resembling most in form *A. mcgregori* Schultze, very pronouncedly and remotely striate-punctate with oblong scale spots partially arranged in three transverse rows. Each elytron at the base with three irregular scale spots, four further ones before the middle and three others behind the middle; besides, in the apical fourth, a large triangular spot connected at the outer margin to a scale stripe extending to the base. Between the third

transverse row and the apical spot is also a small sutural spot. The above-mentioned spots have the tendency to unite into rudimentary longitudinal stripes. Mesosternum and metasternum laterally scaled.

Male, length, 10.2 mm; width, 4.5.

Female, length, 11.3 mm; width, 5.6.

NEGROS, Oriental Negros, Cuernos Mountains (*J. W. Chapman*).

I dedicate this interesting species to its discoverer, Dr. J. W. Chapman, enthusiastic myrmecologist of Silliman Institute.

**PROAPOCYRTUS LUZONICUS sp. nov. Plate 1, fig. 13.**

Black, elytra with the exception of the lateral margins, and femora with the exception of the apical parts, and tibia, red-brown. Rostrum minutely scatteredly punctate, at the base divided from the front by a pronounced transverse groove, in the basal part with a fine mesolongitudinal groove crossing the transverse groove and continuing on the front. The latter also minutely scatteredly punctate. Sides of head with several scattered pale green scales. Prothorax subcylindrical, as long as broad, evenly, densely, but shallowly and roundly, coriaceously granulate, the granulation somewhat more minute than in *P. insularis* Schultze;[9] side above the fore coxæ with a large spot-like scale swarm. Elytra dorsally flat and uniformly bulging, laterally from the base to the middle pronouncedly divergingly bulging, in the apical fourth laterally compressed so that the latter forms a beak-shaped projection. Elytra very coarsely striate-punctate, the punctures confused laterad. Along the lateral margins several small groups of pale green scales. Meso- and metathorax as well as first abdominal segment on either side with a pale-green scale swarm.

Male, length, without rostrum, 12.5 mm; width, 5.8.

LUZON, Rizal Province, Mount Irid.

**METAPOCYRTUS (SPHENOMORPHOIDEA) CASIGURANUS sp. nov. Plate 1, fig. 16, female; Plate 2, fig. 26, male; 27, female.**

Metallic coppery red shining; elytra with violet sheen and pale green scale markings. Rostrum minutely scatteredly punctate, constricted in the basal half, with a strongly pronounced mesal groove, which in the male ends at the base, and in the female extends to the front of head. Prothorax somewhat longer than broad, smooth, with scale stripes at the anterior and pos-

[9] Philip. Journ. Sci. § D 13 (1918) 371, pl. 1, fig. 1.

terior margins as well as a spotlike stripe laterally above the fore coxæ; in the male these markings are reduced and less clearly defined. Elytra irregularly striate-punctate. Elytron in the female with two basal oblong-oval scale spots, and between these a shortened longitudinal stripe extending to the second transverse row of spots. The second tranverse row consists of a larger transverse spot on the disk and four additional spots, of which the third, lying near the lateral margin, is larger and wedge-shaped. The third transverse row consists of five spots of which that lying at the lateral margin is very elongate and stripelike. Next to the apex is a larger transverse spot, and in the apical third a sutural spot common to both elytra. In the male the elytral markings are also strongly reduced, in part only fragmentary, the shortened longitudinal stripe in the basal half is absent. Underside of prothorax and mesothorax laterally scaled.

Male, length, 7.8 mm; width, 3.

Female, length, 10.5 mm; width, 5.

LUZON, Tayabas Province, Casiguran.

This species was collected from the same shrubs as *Pachyrrhynchus rizali* sp. nov., which it superficially resembles.

**METAPOCYRTUS (SCLEROCYRTUS) HERREI sp. nov. Plate 2, fig. 18.**

Glossy black, covered with pink scale-swarms. Related to *M. celestinoi* Schultze and *chamissoi* Schultze. Rostrum as long as broad, basal half diverging anteriorly, dorsally curved and densely scattered-punctate, with a mesal groove which in the form of a pitlike depression extends to the sharply defined basal transverse groove and then continues on the front. Sides of head with a sickle-shaped scale spot. Front with a larger irregular scale swarm. Prothorax somewhat broader than long, the greatest width at the posterior margin, with shining irregular callosities which laterally disintegrate to tuberclelike eroded elevations. The depressed intervals filled with scale swarms, which are very dense laterally. The sculpture of the elytra similar to that of the prothorax, but the tuberclelike elevations more pronounced and arranged more in a longitudinal striate manner. Each elevation bears a short white hair. The depressed intervals beset with scale swarms, which toward the lateral margins are extremely crowded. Legs beset with fine white hairs.

Female, length, 10.7 mm; width, 5.

SAMAR, Burgos (*A. W. Herre*).

*Metapocyrtus herrei* may be easily distinguished from the above-mentioned related species by the absence of band markings. I dedicate this species to my friend and former colleague Dr. A. W. Herre, formerly ichthyologist in the Bureau of Science, Manila.

**METAPOCYRTUS (ORTHOCYRTUS) DIBAGONUS** sp. nov. Plate 2, fig. 12, male; 13, female.

Closest to *M. tumoridorsum* Chevr., although the form of the elytra in the female is shorter and more compressed-ovate. Black with sparse pale greenish white scaling. Rostrum densely scatteredly punctate, and minutely setose, in the basal half with two diverging longitudinal callosities and a mesal depression. Front more coarsely scatteredly punctate, sparsely pubescent, with a fine mesal groove. Prothorax pronounced scarred-punctate and coriaceously rugose; sculpture coarser than in *M. tumoridorsum* Chevr.; several scattered scales only laterally above the fore coxæ. Elytra fairly evenly scatteredly scarred-punctate. From each puncture emerges a short white hair, the pubescence in the apical part somewhat longer. In the female the scaling forms indistinct transverse bands, basally and medially; in the male it is much scattered. The mammælike elongation in the female is less marked than in the above species. The short and compressed form of the elytra of *M. dibagonus* also suggests *M. brevicollis* Chevr.

Male, length, 9.6 mm; width, 4.

Female, length, 10 mm; width, 4.5.

LUZON, Nueva Vizcaya Province, Mount Dibago and Mount Alzapan.

**METAPOCYRTUS (ORTHOCYRTUS) PROLONGATUS** sp. nov. Plate 2, fig. 16, female; 17, male.

Related to *M. tumoridorsum*[10] Chevr. Black with more or less dense scattered greenish white scales. Rostrum intricate and densely rugose-punctate, sparsely white pubescent, with a shallow longitudinal pit beset with a scale swarm. Rostrum divided from the front by a straight transverse groove. The latter scatteredly punctate and scatteredly scaled, with a very fine mesal groove. Sides of head more densely white pubescent. Prothorax in the male relatively larger than in the female, evenly densely rugose-punctate, moderately densely scatteredly scaled and beset with extremely fine white hairs. On the

[10] Chevrolat, Le Natur. (1881) 382; Schultze, Philip. Journ. Sci. 26 (1925) 180, pl. 2, fig. 17, female.

disk with an indistinct, in the male narrow, in the female broader, smooth longitudinal median callosity. Elytra in the male densely punctate and coriaceously rugose; in the female remotely scatteredly scarred and indistinct striate-punctate, the rugosity only faintly marked. Form of elytra in the male normally ovate, in the female mammælike elongated in the apical part, from there sloping abruptly to the apex. In both sexes the apical part of the elytra toward the lateral margins beset with fine, moderately long, white hairs. Mesosternum and metasternum in the male densely white pubescent, in the female more faintly so.

Male, length, 11.5 mm; width, 5.

Female, length, 12.6 mm; width, 5.5.

LUZON, Laguna Province, Mount Banahao (*W. Schultze*).

The female of *M. prolongatus* sp. nov. may be distinguished from that of *M. tumoridorsum* Chevr. especially by the more elongate form, the fainter sculpture, and the pubescence of the prothorax as well as of the elytra. In *M. tumoridorsum* the scaling of the prothorax is sparser, that of the elytra in the basal part more marked. Furthermore, the form of the elongation of the elytra in the latter species is more dual, in *prolongatus* evenly rounded mammælike elongated. Unfortunately, I have before me only four females of *M. tumoridorsum* Chevr.; namely, one specimen (ex coll. Faust) from the Dresden Museum, without a definite locality, and three from Mount Moises, Isabela Province, Luzon.

**METAPOCYRTUS (ORTHOCYRTUS) TUMOROSUS sp. nov. Plate 2, fig. 14, male; 15, female.**

Related to *M. tumoridorsum* Chevr., but immediately distinguishable, especially the female, from that species, by the broader, laterally more pronouncedly distended, dorsally somewhat flattened prothorax, similar to *M. brevicollis* Chevr. Rostrum densely and evenly rugose-punctate with pronounced mesal longitudinal groove scatteredly scaled. Front more minutely rugoso scatteredly punctate with a fine mesal groove. Sides of head with a swarm of oblong, pale greenish white scales. Prothorax moderately pronounced evenly coriaceously rugose and scatteredly scaled. Elytra intricate and indistinct striate-punctate, in the male the indistinct interstices somewhat more longitudinally, callositylike raised; scaling indistinct longitudinally striate. In the female the tumorlike or mammælike projection at the apical sutural slope laterally somewhat compressed,

appearing slightly dually rounded. The apical slope similar to *M. prolongatus* Schultze. Apical part of the elytra, especially the sutural slope, beset with longish white hairs.

Male, length, 11 mm; width, 4.8.

Female, length, 11.2 mm; width, 5.5.

LUZON, Rizal Province, Mount Irid.

**METAPOCYRTUS (ORTHOCYRTUS) MUMUNGANUS sp. nov. Plate 2, fig. 19, male; 20, female.**

Related to *M. virens* Heller. Black with metallic golden or greenish bronze scale markings. Rostrum irregularly scatteredly punctate, with two longitudinal callosities diverging anteriorly and a scaled mediolongitudinal groove. Rostrum divided from the entirely golden scaled front by a deeply marked V-shaped basal-transverse groove. Sides of head also scaled. Prothorax subglobular, next to the base laterally slightly constricted, coarsely flattened granulate; sculpture in the female more faintly outlined. Discal part, with the exception of a narrow longitudinal medial bare stripe, densely scaled between the granulations. A narrow scale stripe at the anterior margin unites on the sides with a large, sharply delimited transverse spot. Elytra strongly but rather irregularly double striate-punctate, with a broad scaled crossband at the base and before the middle, as well as a very large scale spot in the apical third. The bands, as well as the spot, do not cross the suture, but extend only to the second or first puncture row of each elytron. In the female, apical third of the suture with several sharp setæ surrounded by several scales. Apical part of the femora as well as the external side of the tibia with golden scales. Meso- and metathorax laterally also with golden scales.

Male, length, 8.4 mm; width, 4.

Female, length, 9.5 mm; width, 4.7.

MINDANAO, Lanao Province, Mumungan.

**METAPOCYRTUS REYESI [11] DACONUS subsp. nov.**

Black, with reddish golden scale markings in position as in the type. The sculpture very similar to that of the latter but more faintly pronounced.

NEGROS, Oriental Negros, Lake Daco (*J. W. Chapman*).

[11] Schultze, Philip. Journ. Sci. 26 (1925) 198, pl. 5, fig. 25, male; 26, female; pl. 12, fig. 10.

The above local race of *M. reyesi* is in appearance very similar to *Pachyrrhynchus negrosensis* Schultze and stands in a mimicry relationship to this species.

**METAPOCYRTUS (METAPOCYRTUS) IRIDANUS sp. nov.** Plate 2, fig. 10, male; 11, female.

Black with light blue scale spots; related to *M. gibbirostris* Waterh. Rostrum in the male dorsally flat with a shallow impression, minutely scatteredly punctate, divided from the front by a fine transverse groove. The impression with a small scale spot and a small spot at the transverse furrow. Back of rostrum in the female markedly inflated, slightly concave with a longitudinal groove in the basal half; the swelling ends in a blunt tubercle-shaped hump at the base, terraced off from the front; the latter in the male finely and sparsely scattered-punctate with a short mesal groove; in the female, scarred punctate with a long mesal groove. Sides of head with a scale swarm. Prothorax broader than long, the sides evenly rounded, markedly and uniformly coriaceously shagreened, this sculpture coarser in the female and more irregularly outlined. The scale markings consist of an anteromarginal stripe, which on the sides above the fore coxæ expands spotlike and extends to the posterior margin; on either side of the middle, next to the posterior margin, a larger roundish spot. Elytra with marked, somewhat irregular, longitudinal double puncture rows. Each elytron with three transverse rows of roundish or oval scale spots, which are laterally more or less confluent. The first or basal transverse row consists of two spots of which a larger oval lines between the first and third spatia, the other, placed more laterally, is more or less united with a lateromarginal stripe, extending to the apical fourth. The second or third transverse row consists of three spots of which that lying on the disk is roundish, and the other two, more lateral, are more or less crossbandlike confluent with the lateromarginal stripe. In the third transverse row, in the apical third, the external spot is also united with the lateromarginal stripe. Next to the apex is another spot besides the one mentioned above. Posterior elytral slope in both sexes uniformly rounded, female in the apical part with several long white hairs. Legs uniformly white pubescent.

Male, length, 11 mm; width, 4.3.

Female, length, 11 mm; width, 5.

LUZON, Rizal Province, Mount Irid.

**METAPOCYRTUS (METAPOCYRTUS) SUBPILOSUS sp. nov. Plate 2, fig. 9, female.**

Related to *M. pilosus* Schultze.[12] Black with sparse pale green scaling. Rostrum rugose-punctate, with indistinct longitudinal groove continuing on the front. The latter scatteredly punctate, and, like the rostrum, finely pubescent. Prothorax subglobular, relatively much smaller, in both sexes, than in *M. pilosus* Schultze; uniformly coriaceously rugose-punctate, the sculpture finer than in the above species, with a few scattered scales next to the anterior and posterior margins and on the sides. The gray pubescence very similar to that of *M. pilosus* Schultze, only somewhat finer and longer. Elytra fairly regularly striate-punctate, suture at the base, especially in the female, markedly inflated; the interstices slightly moldinglike raised and faintly rugose, more pronounced in the female. From each puncture emerges a short hair, finer than in the above species. In the female at the posterior sutural slope a slight swelling, beset with a tuft of longish hairs. Elytra with more or less scattered scales on the sides, forming in the female a very indistinct basal, median, and ante-median crossband.

Male, length, 10 mm; width, 4.

Female, length, 10 mm; width, 4.6.

LUZON, Rizal Province, Mount Irid.

**METAPOCYRTUS (DOLICHOCEPHALOCYRTUS) DUYAGI sp. nov. Plate 2, fig. 1, male; 2, female.**

Black with sparsely scattered pale bluish or greenish scales. Related to *M. frosti* Schultze and to *M. elicañoi* Schultze, although closer to the latter species. In the male, rostrum with the mesal longitudinal groove more pronounced than in *M. elicañoi,* before the basal transverse groove on either side swollen, sides before the eye with an oblong triangular pronounced depression; in the female, rostrum in the basal part humplike rounded swollen, also more pronounced than in the above species. Prothorax in both sexes uniformly flattened granulate, the granulation coarser and more flattened than in the above species, and with very fine short white hairs between the granulations. Elytra moderately, densely and irregularly striate-punctate and slightly rugose, from each puncture emerges a fine short hair. Apical elytral slope of the female less abrupt than in *M. elicañoi.*

[12] Philip. Journ. Sci. 26 (1925) 195, pl. 11, figs. 21, 22.

Male, length, 10.4 mm; width, 4.4.
Female, length, 10.5 mm; width, 4.6.
LUZON, Rizal Province, Mount Irid.

**METAPOCYRTUS (TRACHYCYRTUS) SUBSPINIPES** sp. nov. Plate 2, fig. 7, male; 8, female.

Related to *M. spinipes* Chevr., and very similar to the latter in scale markings, more elongate in the elytra. Elytra black and legs dark brown. Rostrum densely intricately rugose punctate, with an indistinct longitudinal depression, divided from front by a marked basal transverse groove. Front more sparsely punctate, with a fine longitudinal groove. Rostrum as well as front remotely though evenly beset with fine white hairs which are directed toward the longitudinal middle. Prothorax very evenly rounded granulate, between the granulations remotely beset with fine white hairs, sides with a few scattered pale greenish white scales. Elytra with tuberclelike or slightly rasplike sculpture coarser than in *M. spinipes* Chevr. and beset with fine hairs, which in the last-mentioned species are much finer and sparser. Each elytron with a greenish white scale crossband at the base, triangularly expanded toward the lateral margin, and an irregular scale swarm medially on the elytra, at the lateral margin. In the female the posterior elytral slope at the suture slightly humplike swollen and beset with short robust setæ. Underside and legs also beset with whitish hairs, which are somewhat longer than those of the elytra.

Male, length, 9.8 mm; width, 4.
Female, length, 11 mm; width, 4.6.
LUZON, Cagayan Province, Peñablanca.

**METAPOCYRTUS (TRACHYCYRTUS) MULTIMACULATUS** sp. nov. Plate 2, fig. 25, female.

Black with pale bronze green scale spots and on account of the markings similar to *M. calavitensis* Schultze in appearance, but immediately distinguishable from the latter by the difference in form and sculpture. Rostrum diverging anteriorly, minutely intricately scatteredly punctate with two more strongly diverging longitudinal callosities which at the base slope off laterally. Between the callosities a slight depression with several scales. Front divided by a deeply marked basal transverse groove, with an indistinct mesal groove densely scaled. Prothorax coarsely and densely flattened granulate with a slight mesal

groove, the granulation on the sides finer, more remote, and more rasplike granulate. At the anterior margin an irregular scale stripe which continues to the posterior margin over the fore coxæ, and laterally from the middle ends as a shortened longitudinal stripe. Elytra coarsely and irregularly striate-punctate with a scale stripe at the outer margin spotlike expanded at the base; a basal spot, with two further spots before the middle and in the apical third, respectively, forming a transverse row, and an oblong spot in the apical triangle. Posterior elytral slope along the suture with a double row of short black setæ, more faintly outlined in the male. Apical third of the femora above with an oblong scale spot.

Male, length, 9.5 mm; width, 3.

Female, length, 10 mm; width, 4.2.

LUZON, Isabela Province, Mount Moises.

**METAPOCYRTUS (TRACHYCYRTUS) TRISTIS** sp. nov. Plate 2, fig. 3, male; 4, female.

Related to *M. turgidofemoralis* Schultze and like it of elongate form. Black with cream-colored or pale greenish scattered scaling, and fine, uniform, moderately dense, short gray pubescence. Rostrum finely and densely intricately punctate with two not sharply outlined longitudinal callosities and a dimple which is longer in the male and shorter in the female. Sides of rostrum before the eyes with a deep practically triangular impression. Front divided from the rostrum by a sharply pronounced basal transverse furrow, scattered-punctate and with a fine mesolongitudinal groove. Prothorax pronouncedly and uniformly coriaceously rugose, with sparse scattered scaling, which on the sides becomes denser and more even. Elytra oblong oval, intricately and faintly rugose striate-punctate, in the male less dense and more finely scaled, in the female dense and coarsely scaled. The fine pubescence shorter than that of the prothorax. Elytra in the female at the apical sutural slope with a dual wartlike protuberance, then the suture falling off abruptly and slightly concavely to the apex, the apical part of the elytra longer pubescent and reduced to a blunt point. Posterior elytral slope in the male normally rounded.

Male, length, 9 mm; width, 3.3.

Female, length, 10.2 mm; width, 3.8.

LUZON, Nueva Vizcaya Province, Balete Pass (*W. Schultze*).

**METAPOCYRTUS (TRACHYCYRTUS) CORPULENTUS** sp. nov. Plate 2, fig. 5, female.

Black with cream-colored scale markings, in the female the elytra of very short compressed-ovate form. Rostrum minutely scattered-punctate, slightly swollen, with two longitudinal callosities converging toward the basal transverse groove, and a longitudinal impression on either side between the callosity and the lateral margin. Front minutely and densely rugose punctate with a fine median furrow. Prothorax very uniformly coarsely granulate, between the granulations sparsely, on the sides more densely, scaled. Elytra faintly rugose granulate, the granulation toward the sides more pronounced and more pointed-granulate outlined, with three irregular scale crossbands confluent along the lateral margins. In the female, at the beginning of the apical sutural slope with a tuberclelike swelling beset with a dual tuft of pale reddish hair. Sutural slope falling off vertically to the apex.

Female, length, 8 mm; width, 4.

NEGROS, Occidental Negros, Fabrica (*W. Schultze*).

A somewhat isolated species.

**METAPOCYRTUS (TRACHYCYRTUS) PERARMATUS** sp. nov. Plate 2, fig. 21, male; 22, female.

Related to *M. spinipennis* Schultze and *crassispinosus* Schultze. Black with remotely scattered white scaling. Rostrum minutely, densely and intricately punctate, in the male flattened with a small roundish dimple in the basal half, in the female toward the lateral margins more rounded, the rostrum constriction at the base diminishing laterally; above the antennal pit is an impression threaded by pronounced longitudinal rugosities. Front scattered punctate, sparsely beset with white hairs, and with a pronounced median furrow. Prothorax, in the male, broader than the elytra, uniformly densely rounded granulate, between the granulations—which in the male are coarser—scattered white scales and very fine white hairs. Elytra irregularly striate-punctate and faintly rugose with more regular, remotely scattered, white scales. In the female, the suture at the beginning of the apical elytral slope callously swollen and densely setose, but not forming protuberances as in *M. spinipennis* and *crassispinosus*. Apex of each elytron ending in a short compressed conical point. Between the points a triangular interval which is larger than the corresponding one of the female of

the above-mentioned species. Elytra in the apical part, in both sexes, beset with rather long scattered hairs.

Male, length, without rostrum, 8.3 mm; width, 3.5.

Female, length, 10.4 mm; width, 4.5.

PANAON ISLAND, south of Leyte (*G. Böttcher*).

The above species was obtained through the kindness of Hofrat Prof. Heller, who proposed the name given above.

**METAPOCYRTUS (TRACHYCYRTUS) ALABATANUS sp. nov. Plate 2, fig. 23, male; 24, female.**

Closely related to *M. macrospinosus* Schultze. Black with golden scaled crossbands. Rostrum in the male somewhat longer than in the female, densely and irregularly punctate, constricted at the base, with a longitudinal impression which is somewhat shortened in the female. Front scattered punctate with a sharply outlined mesal groove. Prothorax densely flattened granulate, as in *M. macrospinosus,* but the sculpture more flattened and somewhat more irregular. At the anterior and posterior margins a crossbandlike, more or less dense scale swarm, which is confluent on the sides. Sculpture of the elytra also similar to that in the above species, but less marked; each elytron with three scale crossbands, basally, medially, and next to the apex. These bands are more or less confluent at the lateral margins. In the female, each elytron ending in a conical point, considerably shorter than in the above species; the points of both elytra are pressed against each other and form a triangular continuation, whereas in *M. macrospinosus* they diverge in the last third of their length.

Male, length, without rostrum, 8.4 mm; width, 3.3.

Female, length, 9 mm; width, 3.8.

ALABAT ISLAND, a part of Tayabas Province.

In its scale markings this species resembles *M. acutispinosus* Schultze.

**METAPOCYRTUS (TRACHYCYRTUS) BREVIARMATUS sp. nov. Plate 2, fig. 6, female.**

Related to *M. acutispinosus* Schultze and resembling the latter in its scale markings. Black with metallic pale green scale bands. Rostrum densely scatteredly punctate, in the male with a barely suggested mesal groove, in the female uniformly vaulted without a longitudinal impression. Basal transverse groove deeply marked and ending on the sides in pointlike impressions. Prothorax with a sharply defined anteromarginal groove, pronouncedly flattened transverse rugose, in the male

with an indistinct mesal groove. The scaling is more or less dense, crossbandlike at the anterior and next to the posterior margin and confluent on the sides. Elytra evenly striate-punctate, with three not very sharply delimited scale crossbands, which along the outer margin are more or less confluent, also similar to *M. alabatanus* Schultze. In the female the apical sutural slope with a small dual tuft of short cream-colored hair, each elytron ending in a short, compressed, conical, thornlike point. The points divergent and about one-third the size of those of *M. acutispinosus.* Apical elytral slope in the male normally vaulted; apex of the elytra rounded.

Male, length, 7.5 mm; width, 3.2.

Female, length, 9.5 mm; width, 4.

CATANDUANES ISLAND, Virac.

**CELEBIA SAMARANA** sp. nov. Plate 1, fig. 4.

Glossy black, with light bluish and pale greenish white opalesque scale markings. Rostrum dorsally smooth, only along the lateral margins scattered coarse punctures. Prothorax somewhat broader than long, along the middle on the disk smooth, only in the anterior half with a deep, rather coarse punctiform impression which diminishes into a very much shortened longitudinal groove. Laterally from the middle remotely scattered coarse punctuation and in between irregularly minutely punctate. Prothorax also laterally from the middle with a longitudinal not sharply delimited light bluish scale swarm, on the sides with a larger irregular pale greenish white scale spot and a further smaller spot above the fore coxæ. Scutellum round, knoblike raised, whitely scaled. Elytra striate-punctate, the punctures coarse and deep. Each elytron with two larger scale spots in the basal fourth, one lying between the second and fifth puncture rows, the other, somewhat smaller, along the lateral margin. In the apical half in the second spatium a longitudinal scale stripe extending to the apex, then bending and continuing anteriorly along the lateral margin to the second third of its length. Immediately before the beginning of the longitudinal stripe in the second spatium, and connected with the latter, a fairly large, irregular, and somewhat more posteriorly a small scale spot. Laterally from the former between the fifth and ninth puncture rows a further, larger, very irregular spot, and posteriorly a small, round, and in the apical triangle an irregular triangular spot, the latter confluent with

the lateral marginal stripe. A small fragmentary spot antemedially in the eighth spatium. The entire underside more or less pronouncedly scaled. Tibia on the underside short, white setose.

Length, with rostrum, 18.5 mm; width of elytra, 7.6.

SAMAR, Borongan.

By its conspicuous markings this interesting species is easily distinguishable from the two other known Philippine species of this genus; namely, *C. merrilli* Schultze[13] and *iligana* Schultze.[14] With the last-mentioned species and *C. lactospreta* Heller[15] it forms another link in the chain of New Guinea-Molucca elements in the Philippine fauna.

**COPTORHYNCHUS ORNATUS sp. nov. Plate 1, fig. 10.**

Glossy black with white scale markings. Rostrum dorsally appearing longitudinally somewhat compressed on account of the large antennal scrobes. Along the lateral margins with a row of coarsely confluent punctures, mesally with a shallow groove. Rostrum divided from front by a V-shaped groove. On either side between this groove and the eyes a small triangular scale patch. Front scatteredly punctate. Prothorax somewhat longer than broad, the sides pronouncedly rounded; laterally, at the anterior margin slightly, at the posterior margin pronouncedly, constricted, flattened on the disk; extremely coarsely, evenly densely, and confluent punctate. On either side of the middle a short longitudinal stripe continuing on the anterior margin and then uniting as a stripe over the fore coxæ with a posteromarginal stripe, which again sends off two short branches on either side of the middle anteriorly. Elytra pronouncedly striate-punctate with netlike scale markings which on both elytra circumscribe about fifteen areas. Each elytron with three longitudinal stripes and lateromarginal stripe. The first longitudinal stripe along the suture, extending from the middle to the apex; the second, in the third spatium from the base to the first fourth; the third in the fifth spatium from the basal fourth to the lateral margin. The longitudinal stripes are united with each other by crossbands, which, however, are partially briefly interrupted or spotlike disintegrated. A crossband at the base, a second in the first fourth unites the short basal longitudinal stripe with the third and then runs to the lateromarginal stripe; a third crossband extends from the su-

[13] Philip. Journ. Sci. 15 (1919) 557, pl. 1, fig. 16.

[14] Deutsche Ent. Zeitschr. (1922) 44, pl. 2, fig. 5.

[15] Mem. della Ent. Italiana 3 (1924) 185.

tural stripe to the marginal stripe; a fourth crossband behind the middle, linearly unites the sutural stripe with the third longitudinal stripe, and then, after a slight curve, with the lateromarginal stripe; a fifth crossband, in the apical fourth, extends from the sutural stripe to the third longitudinal stripe. The underside of the prothorax and of the mesothorax also scaled, metathorax and first abdominal segment only laterally.

Length, without rostrum, 11 mm; width of elytra, 5.7.

LUZON, Camarines Norte Province, Paracale (*W. Schultze*).

*Coptorhynchus ornatus* is easily distinguishable from the other species of this genus by its peculiar scale markings, which very strongly suggest certain pachyrrhynchids.

**ALCIDES DUYAGI** sp. nov. Plate 1, fig. 11.

Body subcylindrical; related to *A. kalinganus* Schultze. Head, prothorax, and legs metallic shining, brownish bronze, elytra shiny green-bronze, with creamy white tomentose markings. Prothorax evenly densely punctate, on either side of the middle at the anterior margin on the shallow constriction a small roundish, and more laterally, a somewhat larger tomentose spot, at the posterior margin beginning laterally of the scutellum a toment stripe which expands a little toward the sides. Laterally above the fore coxæ a narrow longitudinal stripe. Elytra with very uniform puncture rows, the punctures oblong. Beginning at the scutellum and the suture, directed posteriorly, a narrow tomentose crossband, which, describing a smooth arc, extends to the lateral margin. Behind the middle a further narrow crossband extends laterally from the suture to the eighth puncture row, then bends and continues in the ninth interstice to near the apex, where it unites, in the third interstice, with a short longitudinal stripe.

Length, without rostrum, 11.8 mm; shoulder breadth, 4.9.

LUZON, Nueva Vizcaya Province, Santa Fé (*W. Schultze*).

I dedicate this beautiful species to Anacleto Duyag, who has been my collector for many years.

**ALCIDES NEGROSENSIS** sp. nov. Plate 1, fig. 15.

Related to *A. pectoralis* Boh., which it resembles very much in body form, but from which it is easily distinguishable by the markings. Black with pale yellow crossbands. The toment consists of very short hairs covered with a pollenlike substance. Rostrum in the apical half minutely and densely, toward the base coarsely and intricately, punctate. Front very densely punctate and with a dimplelike impression. Prothorax, with

the exception of a narrow border along the anterior margin, extremely coarsely eroded granulate, with a narrow tomentose band in the shallow constriction near and along the anterior margin, and a further band along the hind margin. Both bands somewhat expanded laterally. Elytra with very pronounced groovelike puncture rows, the intervals rounded, pronouncedly moldinglike prominent. Each elytron medially with a crossband, extending from the second puncture row to the lateral margin and toward the latter wedgelike expanded. In the apical third on the third interstice a longitudinal stripe, which before the apex curves like a short hook anteriorly at the lateral margin. Underside almost entirely more or less markedly tomentose.

Length, without rostrum, 9.8 mm; shoulder breadth, 4.3.

NEGROS, Oriental Negros, Lake Daco.

**ALCIDES SUBCUPRINUS** sp. nov. Plate 1, fig. 9.

Related to *A. cuprinus* Heller[16] and *kalinganus* Schultze. Metallic coppery shining with cream-colored tomentose markings, in the female the ground coloring with a strongly iridescent violet shimmer. Prothorax densely and evenly punctate, at the anterior margin above the lateral constriction on either side an irregular round tomentose spot, a further crescent spot on either side at the posterior margin, and on the sides above the fore coxæ an irregular spot. Punctuation on the sides more coarse and intricate. Each elytron with nine sharply defined and very regular puncture rows. The individual punctiform impressions elongate, more resembling short dashes. Each elytron in the basal part with a tomentose band, which from the suture extends, circumscribing the scutellum, in the shape of a curve to the lateral margin, but is interrupted between the fourth and fifth puncture rows and thus forms two large transverse spots. A further crossband, curved somewhat forward, behind the middle, extending from the first to the ninth puncture rows; next to the apex a broad V-shaped tomentose spot. The underside of the prothorax and of the mesothorax tomentose, as well as the metathorax and abdominal segments, especially laterally.

Male, length, without rostrum, 13 mm; shoulder breadth, 5.2 mm.

Female, length, 12.7 mm; shoulder breadth, 5.3.

[16] Stett. Ent. Zeitung 78 (1917) 241. Of this species from an unknown locality, I have before me three specimens from Peñablanca, Cagayan Province, Luzon.

LUZON, Ilocos Norte Province, Mount Palimlim, 1 male; Bangui, 1 female.

**ALCIDES LAGUNENSIS** sp. nov. Plate 1, fig. 12.

Related to *A. semperi* Pascoe, which it resembles very much in bodily form. Metallic steel-blue with whitish tomentose spots consisting of fine hairs. Rostrum in the apical half very minutely scatteredly punctate, basal half densely and rugose confluent punctate with a shallow mesal groove, which projects to front in the form of a dimple. Prothorax irregularly, minutely, and scatteredly punctate. On either side of the middle and behind the lateral constriction next to the anterior margin with a spotlike expanded transverse band extending to the fore coxæ. A further tomentose spot on either side at the posterior margin and a small round tomentose spot medially above the scutellum. Elytra irregularly coriaceously rugose with fine sharp puncture rows. Each elytron with ten tomentose spots of which seven are irregularly confluent, forming two transverse bands, one basal and one behind the middle. The basal transverse band consists of four confluent spots, of which three form a row; the fourth, however, is confluent with the second anteriorly and extends to near the base. The second transverse row of three spots behind the middle is more uniform. A third transverse row in the apical third consists of two spots and at the apex is another small tomentose spot. Underside of prothorax tomentose, mesothorax and metathorax as well as abdominal segments laterally.

Length, without rostrum, 12 mm; shoulder breadth, 5.

LUZON, Laguna Province, Paete (*W. Schultze*).

# ILLUSTRATIONS

## PLATE 1

[Original crayon drawings by W. Schultze. All figures magnified 2 : 1.]

FIG. 1. *Acronia luzonica* sp. nov.
2. *Macrocyrtus trilineatus* sp. nov.
3. *Cylindrepomus sexlineatus* sp. nov.
4. *Celebia samarana* sp. nov.
5. *Niphonoclea ornata* sp. nov.
6. *Pseudabryna hieroglyphica* sp. nov.
7. *Proteuclea palawana* sp. nov.
8. *Pseudodoliops schwarzeri* gen. et sp. nov.
9. *Alcides subcuprinus* sp. nov.
10. *Coptorhynchus ornatus* sp. nov.
11. *Alcides duyagi* sp. nov.
12. *Alcides lagunensis* sp. nov.
13. *Proapocyrtus luzonicus* sp. nov.
14. *Apocyrtus chapmani* sp. nov.
15. *Alcides negrosensis* sp. nov.
16. *Metapocyrtus casiguranus* sp. nov.
17. *Pachyrrhynchus rizali* sp. nov.

## PLATE 2

FIG. 1. *Metapocyrtus* (*Dolichocephalocyrtus*) *duyagi* sp. nov., male.
2. *Metapocyrtus* (*Dolichocephalocyrtus*) *duyagi* sp. nov., female.
3. *Metapocyrtus* (*Trachycyrtus*) *tristis* sp. nov., male.
4. *Metapocyrtus* (*Trachycyrtus*) *tristis* sp. nov., female.
5. *Metapocyrtus* (*Trachycyrtus*) *corpulentus* sp. nov., female.
6. *Metapocyrtus* (*Trachycyrtus*) *breviarmatus* sp. nov., female.
7. *Metapocyrtus* (*Trachycyrtus*) *subspinipes* sp. nov., male.
8. *Metapocyrtus* (*Trachycyrtus*) *subspinipes* sp. nov., female.
9. *Metapocyrtus* (*Metapocyrtus*) *subpilosus* sp. nov., female.
10. *Metapocyrtus* (*Metapocyrtus*) *iridanus* sp. nov., male.
11. *Metapocyrtus* (*Metapocyrtus*) *iridanus* sp. nov., female.
12. *Metapocyrtus* (*Orthocyrtus*) *dibagonus* sp. nov., male.
13. *Metapocyrtus* (*Orthocyrtus*) *dibagonus* sp. nov., female.
14. *Metapocyrtus* (*Orthocyrtus*) *tumorosus* sp. nov., male.
15. *Metapocyrtus* (*Orthocyrtus*) *tumorosus* sp. nov., female.
16. *Metapocyrtus* (*Orthocyrtus*) *prolongatus* sp. nov., female.
17. *Metapocyrtus* (*Orthocyrtus*) *prolongatus* sp. nov., male.
18. *Metapocyrtus* (*Sclerocyrtus*) *herrei* sp. nov., female.
19. *Metapocyrtus* (*Orthocyrtus*) *mumunganus* sp. nov., male.
20. *Metapocyrtus* (*Orthocyrtus*) *mumunganus* sp. nov., female.
21. *Metapocyrtus* (*Trachycyrtus*) *perarmatus* sp. nov., male.
22. *Metapocyrtus* (*Trachycyrtus*) *perarmatus* sp. nov., female.
23. *Metapocyrtus* (*Trachycyrtus*) *alabatanus* sp. nov., male.
24. *Metapocyrtus* (*Trachycyrtus*) *alabatanus* sp. nov., female.
25. *Metapocyrtus* (*Trachycyrtus*) *multimaculatus* sp. nov., female.
26. *Metapocyrtus* (*Sphenomorphoidea*) *casiguranus* sp. nov., male.
27. *Metapocyrtus* (*Sphenomorphoidea*) *casiguranus* sp. nov., female.

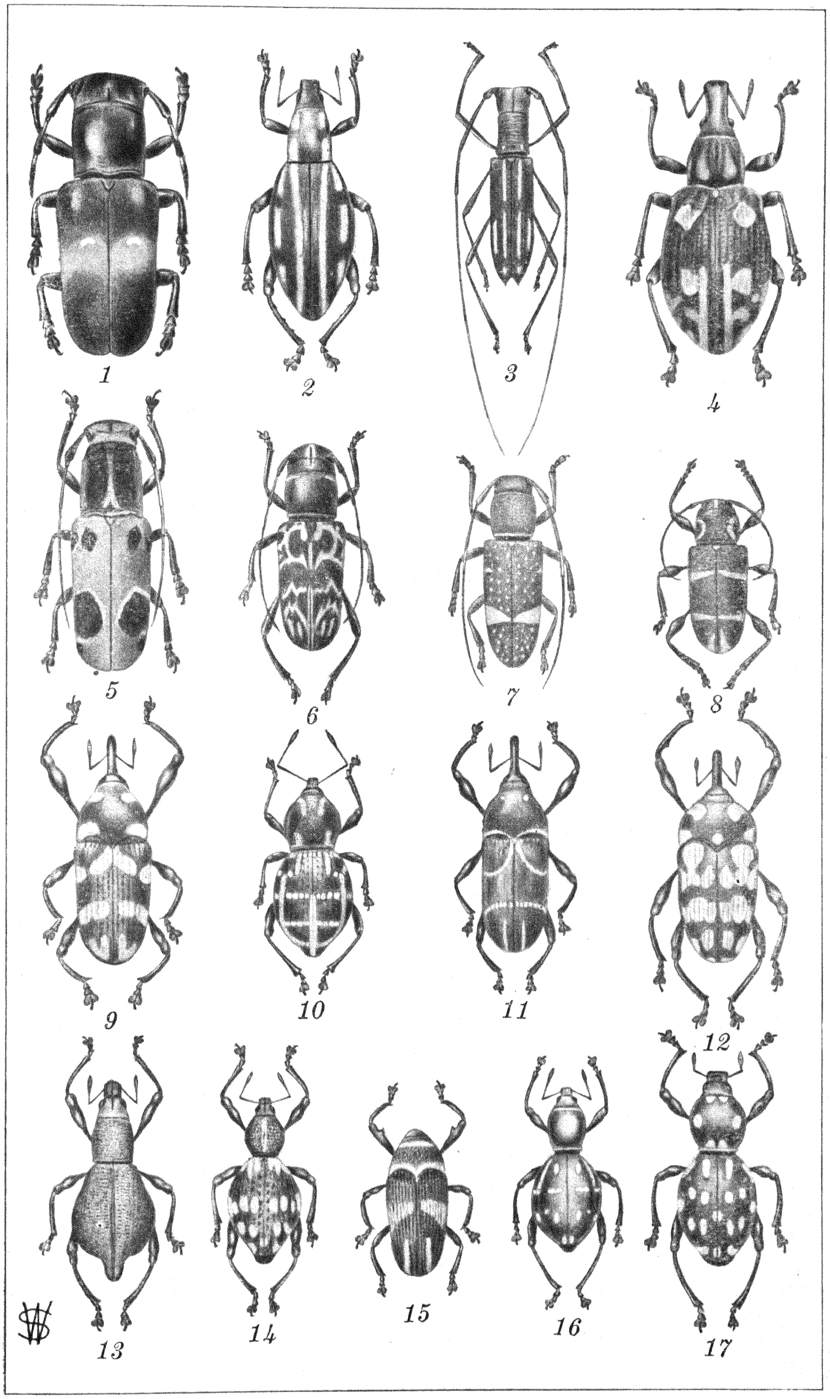


PLATE 1.

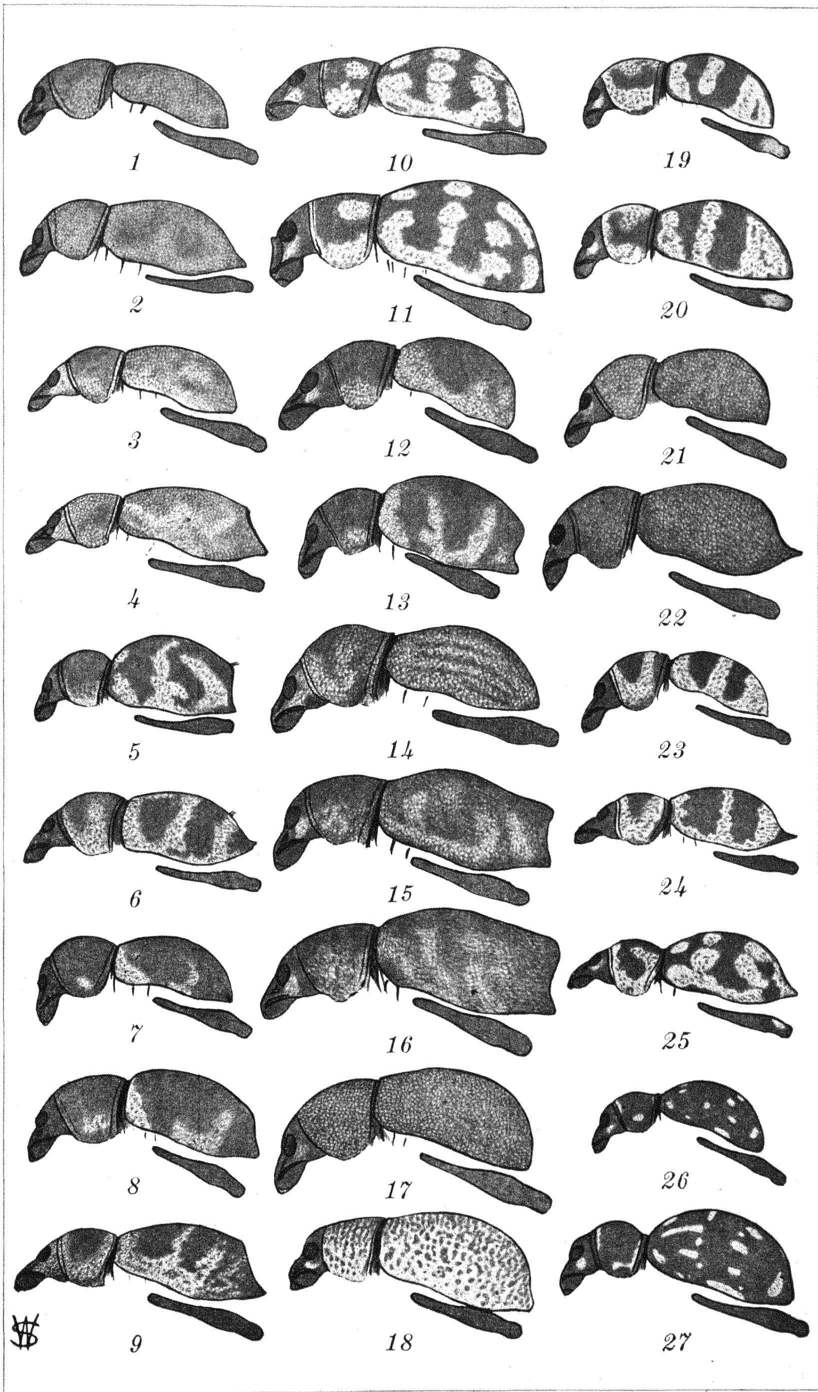

PLATE 2.

# SOLAR ULTRAVIOLET RADIOMETRY

## IV, THE ULTRAVIOLET OF SUNLIGHT IN MANILA[1]

By WM. D. FLEMING

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The question of the suitability of the Tropics as a place of residence for members of the white race is of long standing, has many and varied aspects, and is still to be satisfactorily answered in perhaps any of these aspects. The military bearings of this question for any nation having troops on tropical duty are important and touch on such fundamentals as health, morale, ability to maneuver, and optimum length of tropical tour of duty. Many and most varied opinions have been, and are, held on all these bearings. In reviewing many of these opinions one cannot help but feel that personal prejudice and a great preponderance of subjective evidence, as opposed to objective evidence, have had disproportionate weight in their formation.

In no part of this question have these factors of prejudice and subjective evidence played a greater part than in the matter of the sunlight found in the Tropics. Woodruff's well-known book on Tropical Sunlight is an example of this. In the parts of this book in which the presence of any evidence can be detected, this evidence is wholly subjective.

On the other hand, the very few earlier reports on tropical sunlight available that do deal with objective evidence, are of work done with inadequate apparatus and, in some cases, do not meet the requirements of the present theory of radiation.

The present article records results of an attempt to obtain reliable objective evidence concerning certain fractions of the sunlight in one tropical locality.

The requirement of objectivity of the evidence has narrowed the scope of the investigation greatly. It is hoped that with this narrowing there has been a proportionate gain in reliability and pertinency. Such matters as the effects of this light on humans have necessarily been left untouched. It is fully realized,

[1] Submitted for publication March 9, 1933.

also, that the data deals with only one place, which may differ from other places in the Tropics in many respects. The extreme rarity of sunstroke in Manila in contrast with what is at least believed to be true of some other tropical localities may be cited as such a possible difference. With such aspects, only similar data obtained elsewhere both in the Tropics and in temperate climates can deal. Such work is slowly getting under way in several places in the world, and, in time, will doubtlessly afford an answer. It is desired to place this present work on record as a step in this program.

This report gives a quantitative spectral analysis of certain regions of the ultraviolet and violet of sunlight as found in Manila, P. I., over the period of one year, from February, 1932, to January, 1933, both inclusive. Values are reported in two different forms: as percentages of the total energy of the sunlight between the limits λ 290 and λ 1,400 millimicrons and in microwatts per square millimeter of surface normal to the incident light. The sunlight studied was divided into four different spectral bands as follows:

(*a*) 290 to 310 millimicrons
(*b*) 310 to 370 millimicrons
(*c*) 370 to 400 millimicrons
(*d*) 400 to 460 millimicrons.

The total solar energy was taken as lying between λ 290 and λ 1,400 millimicrons. The short wave-length limit is that usually assumed for sunlight. This was checked spectrographically in the course of this work as reported earlier.(1) The long wave-length limit of 1,400 millimicrons was taken as the limit of transmission of a layer of water 10 millimeters thick. This water filter was necessary to give a sharp upper cut-off to the various glass filters used.

## PROCEDURE

The instruments and methods used have been reported in detail previously.(2) Briefly, the solar energy was measured by a thermopile and galvanometer. The energy fractions in the four spectral bands were determined by the decreased effect in this arrangement when glass filters of known transmission were placed over the thermopile, cutting off part of the energy.

## LOCATION AND CLIMATIC CONDITIONS

Manila lies on the eastern shore of Manila Bay, on the west coast of Luzon, Philippine Islands, 120° 59′ east longitude, 14°

35′ north latitude. The instrumental observations were made on the roof of the building housing the Philippine Weather Bureau, over the third story. A clear view was had of all quarters of the sky.

The climate of Manila may usually be divided into three seasons: cool, hot, and rainy. The cool season usually extends from November through February with generally clear skies, the hot season from March to July with clear skies, and the rainy reason from July through October with very many cloudy days. In 1932, however, cloudy weather was the rule throughout what should have been the clear days of October, November, December, and in January, 1933. As was explained in the article on Instruments and Methods, work could be done only upon the clear sun entirely free from clouds, and when this condition of clearness lasted for at least fifteen minutes. Each individual run of five observations—four spectral bands and one total radiation—lasted between seven and fifteen minutes. Since the spectral bands were determined as percentages of the total, unless the sun remained constant for this length of time, accurate values would not be obtained. Very many runs were started only to be discarded due to a small cloud suddenly obscuring the sun. A certain number of runs were obtained, however, on weak sunlight, the light coming through a heavy but uniform and constant haze. This haze was quite different from formed clouds. The number of days permitting observations is shown in Table A.

TABLE A.—*Number of days permitting observations.*

| Month. | Morning work. | Afternoon work. | Work throughout day. |
|---|---|---|---|
| February | 4 | 1 | 1 |
| March | 6 | 4 | 4 |
| April | 9 | 5 | 4 |
| May | 7 | 4 | 3 |
| June | 5 | 4 | 3 |
| July | 3 | 2 | 0 |
| August | 8 | 7 | 4 |
| September | 3 | 3 | 1 |
| October | 3 | 2 | 1 |
| November | 5 | 2 | 0 |
| December | 7 | 1 | 0 |
| January | 5 | 4 | 4 |
| Total | 65 | 39 | 25 |

Quite apart from these instrumental requirements of constant clear sun it was considered advisable to limit observations to clear sunlight. The reasons for this may be quoted from the previous article on Methods. (2)

The limitation of the method to use with cloudless sun is not regarded as being as objectionable as might first appear. The basic question which this work attempts to answer is the partial spectral composition of sunlight. If this must be limited to sunlight unfiltered by clouds, the results obtained will probably be on a better basis for comparison with results obtained on similar sunlight elsewhere in the world than if the problem were complicated by the intrusion of such factors as comparative cloudiness of different regions. The problem is one of solar radiation and not of sunshine as affected by cloudiness.

The values for Manila now reported will be of value chiefly in comparison with figures that it is hoped will be obtained elsewhere as opportunity offers.

In the later part of the year few observations were made at hours when the air mass was greater than 2.5. For air masses greater than 2.5 the quantities observed are small and the correction factors of the filters become very large and uncertain. This combination makes for too questionable accuracy and renders results of little value.

## TABULATION OF RESULTS

The reported values are shown in two forms for each of the four spectral bands: as percentages of the total solar energy present ($\lambda$ 290 to 1,400 millimicrons) and in microwatts per square millimeter of surface normal to the incident light. The total energy is also given in this last unit. The results are tabulated as the means for each separate month. The columns run by air mass and not by hours. All values for an air mass less than 2.0 (1.0 to 1.95) are summarized in an additional column. Beyond this, values are given for air mass 2.0 (1.95 to 2.4), 3.0 (2.5 to 3.4), 4.0 (3.5 to 4.4), and 5.0 (4.5 to 5.5). Below each value the deviation of the mean is shown, denoted by AD$\pm$.

$$AD = \frac{ad}{\sqrt{n}} \text{ where } ad = \frac{\Sigma d}{n} \text{ and}$$

d = difference between individual value and the mean

n = number of observations.

This AD value is given as a measure of the variability of the light for that particular month and air mass. In each table the mean of all the monthly values is shown for each air mass.

TABLE 1.—*290 to 310 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

| Month. | Air mass. 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 0.051 | 0.054 | 0.032 | | 0.032 | | 0.034 | | | 0.040 | 0.026 | 0.017 | | |
| AD ± | | 0.003 | | | | | | 0.001 | | | 0.002 | 0.001 | 0.001 | | |
| March | 0.098 | 0.074 | 0.067 | 0.059 | 0.042 | 0.041 | 0.036 | 0.035 | 0.030 | 0.029 | 0.056 | 0.018 | 0.018 | | |
| AD ± | | 0.006 | 0.011 | 0.009 | 0.004 | 0.003 | | | 0.001 | | 0.004 | 0.002 | | | |
| April | 0.069 | 0.054 | 0.068 | 0.067 | 0.054 | 0.041 | 0.046 | 0.047 | 0.035 | 0.053 | 0.056 | 0.025 | | | |
| AD ± | 0.006 | 0.004 | 0.010 | 0.007 | 0.006 | 0.005 | 0.007 | | 0.003 | 0.001 | 0.006 | 0.001 | | | |
| May | 0.084 | 0.061 | 0.082 | 0.060 | 0.039 | 0.056 | | 0.053 | 0.039 | | 0.068 | 0.031 | 0.023 | | |
| AD ± | 0.007 | 0.009 | | 0.011 | | 0.006 | | | 0.003 | | 0.007 | 0.006 | | | |
| June | 0.078 | 0.060 | 0.053 | 0.049 | 0.038 | 0.052 | | 0.026 | 0.048 | | 0.059 | 0.028 | | | |
| AD ± | 0.004 | 0.004 | 0.011 | 0.008 | | 0.008 | | 0.000 | 0.001 | | 0.009 | 0.003 | | | |
| July | | | 0.052 | | 0.053 | 0.064 | 0.036 | | 0.031 | 0.020 | 0.046 | 0.028 | | | |
| AD ± | | | 0.010 | | 0.011 | | | | | | 0.013 | 0.008 | | | |
| August | 0.065 | 0.082 | 0.085 | | | 0.055 | 0.052 | | 0.027 | 0.036 | 0.058 | 0.031 | | | |
| AD ± | 0.008 | 0.012 | 0.009 | | | | 0.010 | | | | 0.012 | 0.006 | | | |
| September | 0.103 | 0.084 | 0.053 | 0.041 | | | 0.041 | | | | 0.081 | 0.015 | | | |
| AD ± | 0.002 | 0.009 | 0.016 | | | | 0.016 | | | | 0.009 | | | | |
| October | | 0.073 | 0.066 | 0.054 | 0.058 | | | | | | 0.067 | | | | |
| AD ± | | 0.010 | 0.012 | 0.009 | | | | | | | 0.010 | | | | |
| November | | | 0.082 | 0.078 | 0.073 | 0.043 | 0.066 | 0.051 | | 0.061 | 0.066 | 0.030 | | | |
| AD ± | | | | 0.003 | | | 0.004 | 0.007 | | | 0.004 | 0.002 | | | |
| December | | | | 0.076 | 0.055 | 0.060 | 0.060 | 0.053 | | 0.067 | 0.066 | 0.030 | | | |
| AD ± | | | | 0.003 | 0.001 | 0.006 | 0.002 | 0.003 | | | 0.003 | 0.005 | | | |
| January | | | 0.045 | 0.049 | 0.058 | 0.053 | 0.063 | 0.060 | | 0.045 | 0.052 | 0.039 | | | |
| AD ± | | | 0.010 | 0.004 | 0.003 | 0.007 | | 0.000 | | 0.004 | 0.005 | 0.003 | | | |
| M | 0.083 | 0.067 | 0.064 | 0.057 | 0.052 | 0.050 | 0.050 | 0.045 | 0.035 | 0.044 | 0.060 | 0.027 | 0.020 | | |
| AD ± | 0.004 | 0.004 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 | 0.004 | 0.003 | 0.005 | 0.003 | 0.002 | 0.002 | | |

TABLE 1.—*290 to 310 millimicrons*—Continued.

B. AFTERNOON SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 0.053 | 0.045 | | 0.051 | 0.034 | | | 0.020 | | 0.043 | 0.020 | 0.020 | 0.006 | |
| AD ± | | 0.001 | | | | | | | | | 0.003 | | | | |
| March | 0.092 | 0.070 | 0.059 | 0.064 | 0.054 | 0.036 | 0.047 | | 0.029 | 0.060 | 0.062 | 0.027 | 0.020 | 0.016 | |
| AD ± | | 0.005 | 0.003 | 0.012 | 0.002 | | | | | | 0.005 | 0.001 | 0.007 | 0.003 | |
| April | 0.070 | 0.065 | 0.053 | 0.046 | 0.047 | 0.035 | 0.027 | 0.048 | | | 0.058 | 0.022 | 0.017 | 0.009 | 0.006 |
| AD ± | 0.006 | 0.006 | | 0.006 | 0.009 | | | 0.004 | | | 0.005 | 0.002 | 0.001 | 0.002 | |
| May | 0.080 | 0.085 | 0.078 | 0.052 | 0.074 | | 0.030 | | | | 0.073 | 0.040 | 0.015 | 0.010 | |
| AD ± | 0.010 | 0.014 | 0.006 | 0.002 | | | | | | | 0.009 | 0.001 | | | |
| June | 0.066 | 0.070 | 0.061 | 0.075 | 0.060 | | 0.066 | | | 0.043 | 0.065 | | 0.037 | | |
| AD ± | 0.008 | 0.015 | 0.012 | 0.006 | 0.005 | | 0.000 | | | | 0.010 | | | | |
| July | | | 0.051 | | | 0.055 | 0.030 | | | | 0.047 | | | | |
| AD ± | | | 0.001 | | | | | | | | 0.006 | | | | |
| August | 0.095 | 0.075 | 0.065 | 0.082 | 0.070 | 0.053 | 0.064 | 0.046 | | | 0.075 | 0.043 | 0.026 | 0.022 | |
| AD ± | 0.007 | 0.010 | 0.009 | 0.014 | | 0.010 | | 0.009 | | | 0.009 | 0.006 | 0.006 | 0.003 | |
| September | 0.088 | 0.087 | | | | 0.026 | | | 0.017 | | 0.065 | 0.015 | | | |
| AD ± | 0.001 | 0.002 | | | | | | | | | 0.001 | | | | |
| October | | 0.080 | 0.072 | | 0.057 | | 0.053 | | | | 0.069 | 0.040 | | | |
| AD ± | | 0.001 | 0.004 | | | | | | | | 0.003 | | | | |
| November | | | | 0.041 | 0.066 | 0.011 | | | | | 0.019 | | | | |
| AD ± | | | | 0.012 | | | | | | | 0.009 | | | | |
| December | | | | 0.076 | | | | | | | | | | | |
| AD± | | | | 0.004 | | | | | | | | | | | |
| January | | | 0.048 | 0.052 | 0.042 | 0.051 | | 0.045 | | | 0.049 | 0.037 | | | |
| AD ± | | | 0.006 | 0.008 | | 0.009 | | | | | 0.007 | 0.012 | | | |
| M | 0.082 | 0.073 | 0.059 | 0.061 | 0.058 | 0.038 | 0.045 | 0.046 | 0.022 | 0.052 | 0.057 | 0.031 | 0.023 | 0.012 | 0.006 |
| AD ± | 0.003 | 0.003 | 0.003 | 0.004 | 0.003 | 0.004 | 0.005 | 0.001 | 0.003 | 0.005 | 0.004 | 0.003 | 0.003 | 0.002 | |

C. TOTAL DAY.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 0.052 | 0.050 | 0.032 | 0.051 | 0.033 | | | | | 0.043 | 0.029 | 0.018 | | |
| AD ± | | 0.002 | 0.004 | | | 0.001 | | | | | 0.003 | 0.003 | 0.001 | | |
| March | 0.095 | 0.072 | 0.063 | 0.062 | 0.047 | 0.040 | 0.042 | | 0.030 | 0.045 | 0.059 | 0.021 | 0.019 | | |
| AD ± | 0.002 | 0.004 | 0.004 | 0.007 | 0.004 | 0.002 | 0.006 | | 0.001 | 0.010 | 0.003 | 0.002 | 0.001 | | |
| April | 0.069 | 0.058 | 0.067 | 0.058 | 0.051 | 0.040 | 0.041 | 0.048 | | | 0.056 | 0.023 | | | |
| AD ± | 0.006 | 0.005 | 0.010 | 0.007 | 0.007 | 0.005 | 0.007 | 0.005 | | | 0.006 | 0.002 | | | |
| May | 0.083 | 0.070 | 0.080 | 0.056 | 0.057 | | | | | | 0.070 | 0.035 | 0.020 | | |
| AD ± | 0.008 | 0.010 | 0.008 | 0.007 | 0.010 | | | | | | 0.008 | 0.004 | 0.014 | | |
| June | 0.075 | 0.065 | 0.057 | 0.060 | 0.053 | | | | | | 0.061 | | | | |
| AD ± | 0.005 | 0.009 | 0.012 | 0.008 | 0.009 | | | | | | 0.009 | | | | |
| July | | | 0.052 | | | 0.060 | 0.033 | | | | 0.046 | | | | |
| AD ± | | | 0.007 | | | 0.002 | 0.002 | | | | 0.011 | | | | |
| August | 0.078 | 0.077 | 0.072 | | | 0.054 | 0.042 | | | | 0.036 | 0.037 | | | |
| AD ± | 0.008 | 0.011 | 0.009 | | | 0.010 | 0.010 | | | | 0.006 | 0.006 | | | |
| September | 0.096 | 0.068 | | | | | | | | | 0.071 | 0.015 | | | |
| AD ± | 0.002 | 0.007 | | | | | | | | | 0.006 | | | | |
| October | | 0.076 | 0.068 | | 0.058 | | | | | | 0.040 | | | | |
| AD ± | | 0.009 | 0.009 | | 0.001 | | | | | | 0.003 | | | | |
| November | | | | 0.063 | 0.070 | 0.027 | | | | | | | | | |
| AD ± | | | | 0.006 | 0.003 | | | | | | | | | | |
| December | | | | 0.076 | | | | | | | | | | | |
| AD ± | | | | 0.003 | | | | | | | | | | | |
| January | | | 0.046 | 0.051 | 0.048 | 0.05 | | 0.055 | | | 0.051 | 0.038 | | | |
| AD ± | | | 0.008 | 0.007 | 0.002 | 0.008 | | 0.006 | | | 0.006 | 0.006 | | | |
| M | 0.083 | 0.067 | 0.062 | 0.051 | 0.054 | 0.044 | 0.039 | 0.052 | 0.030 | 0.045 | 0.053 | 0.028 | 0.019 | | |
| AD ± | 0.003 | 0.002 | 0.003 | 0.003 | 0.002 | 0.004 | 0.002 | 0.002 | 0.001 | 0.010 | 0.003 | 0.003 | 0.001 | | |

TABLE 2.—*310 to 370 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 1.7 | 1.4 | 1.1 | | 1.1 | | 1.1 | | | 1.3 | 1.0 | 0.6 | | |
| AD ± | | 0.04 | | | | | | 0.05 | | | 0.05 | 0.05 | 0.07 | | |
| March | 1.8 | 1.7 | 1.6 | 1.5 | 1.4 | 1.1 | 1.5 | 1.2 | 1.0 | 0.9 | 1.4 | 0.8 | 0.5 | | |
| AD ± | | 0.00 | 0.04 | 0.03 | 0.05 | 0.03 | | | 0.05 | | 0.03 | 0.06 | | | |
| April | 1.8 | 1.7 | 1.6 | 1.6 | 1.4 | 1.2 | 1.3 | 1.3 | 1.0 | 0.9 | 1.5 | 0.8 | | | |
| AD ± | 0.04 | 0.03 | 0.04 | 0.03 | 0.04 | 0.10 | 0.17 | | 0.05 | 0.04 | 0.4 | 0.07 | | | |
| May | 2.1 | 1.9 | 1.6 | 1.8 | 1.1 | 1.4 | | 1.1 | 1.2 | | 1.7 | 0.9 | 0.9 | | |
| AD ± | 0.04 | 0.01 | | 0.05 | | 0.10 | | | 0.00 | | 0.04 | 0.03 | | | |
| June | 2.0 | 1.8 | 1.7 | 1.6 | 1.4 | 1.3 | | 1.3 | 1.1 | | 1.7 | 0.9 | | | |
| AD ± | 0.03 | 0.03 | 0.06 | 0.05 | | 0.03 | | 0.02 | 0.05 | | 0.03 | 0.05 | | | |
| July | | | 1.7 | | 1.5 | 1.3 | 1.4 | | 1.0 | 1.1 | 1.4 | 0.9 | | | |
| AD ± | | | 0.05 | | 0.03 | | | | | | 0.11 | 0.10 | | | |
| August | 1.8 | 1.8 | 1.5 | | | 1.1 | 1.3 | | 1.2 | 1.5 | 1.6 | 0.7 | | | |
| AD ± | 0.05 | 0.04 | 0.10 | | | | 0.10 | | | | 0.20 | 0.12 | | | |
| September | 1.8 | 1.7 | 1.7 | 1.7 | | | 1.2 | | | | 1.7 | 0.9 | | | |
| AD ± | 0.02 | 0.03 | 0.04 | | | | 0.01 | | | | 0.02 | | | | |
| October | | 1.6 | 1.6 | 1.50 | 1.34 | | | | | | 1.59 | | | | |
| AD ± | | 0.01 | 0.01 | 0.04 | | | | | | | 0.01 | | | | |
| November | | | 1.62 | 1.48 | 1.33 | 1.0 | 1.42 | 1.6 | | 1.34 | 0.12 | 1.0 | | | |
| AD ± | | | | 0.01 | | | 0.06 | 0.03 | | | 0.03 | 0.05 | | | |
| December | | | | 1.46 | 1.50 | 1.44 | 1.24 | 1.18 | | 0.93 | 1.36 | 0.73 | | | |
| AD ± | | | | 0.02 | 0.04 | 0.01 | 0.00 | 0.03 | | | 0.02 | 0.07 | | | |
| January | | | 1.53 | 1.58 | 1.37 | 1.22 | 1.14 | 1.09 | | 0.92 | 1.33 | 0.66 | | | |
| AD ± | | | 0.09 | 0.09 | 0.04 | 0.04 | | 0.01 | | 0.03 | 0.06 | 0.06 | | | |
| M | 1.9 | 1.8 | 1.6 | 1.5 | 1.5 | 1.2 | 1.3 | 1.2 | 1.1 | 1.1 | 1.5 | 0.9 | 0.7 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | | |

B. AFTERNOON SUN.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 1.7 | 1.5 | | 1.4 | 1.3 | | | 1.3 | | 1.4 | 0.8 | 0.4 | 0.2 | |
| AD ± | | 0.04 | | | | | | | | | 0.03 | | | | |
| March | 1.9 | 1.8 | 1.7 | 1.7 | 1.2 | 1.5 | 1.3 | | 1.6 | 1.0 | 1.6 | 0.8 | 0.5 | 0.3 | |
| AD ± | | 0.04 | 0.02 | 0.03 | 0.00 | | | | | | 0.03 | 0.02 | 0.02 | 0.04 | |
| April | 1.8 | 1.7 | 1.5 | 1.5 | 1.3 | 1.2 | 0.9 | 1.1 | | | 1.6 | 0.8 | 0.5 | 0.3 | 0.2 |
| AD ± | 0.03 | 0.03 | | 0.04 | 0.02 | | | 0.03 | | | 0.05 | 0.05 | 0.07 | 0.03 | |
| May | 2.1 | 1.9 | 1.7 | 1.7 | 1.3 | | 1.4 | | | | 1.8 | 0.9 | 0.7 | 0.5 | |
| AD ± | 0.05 | 0.08 | 0.01 | 0.03 | | | | | | | 0.04 | 0.00 | | | |
| June | 2.0 | 2.0 | 1.8 | 1.7 | 1.6 | | 1.4 | | | 1.0 | 1.8 | | 0.7 | | |
| AD ± | 0.03 | 0.07 | 0.03 | 0.01 | 0.04 | | 0.02 | | | | 0.04 | | | | |
| July | | | 1.8 | | | 1.5 | 1.6 | | | | 1.7 | | | | |
| AD ± | | | 0.10 | | | | | | | | 0.11 | | | | |
| August | 1.8 | 1.8 | 1.6 | 1.7 | 1.7 | 1.5 | 1.2 | 1.4 | | | 1.7 | 1.0 | 0.6 | 0.3 | |
| AD ± | 0.05 | 0.05 | 0.10 | 0.05 | | 0.10 | | 0.10 | | | 0.10 | 0.05 | 0.04 | 0.03 | |
| September | 1.8 | 1.7 | | | | 1.4 | | | 1.2 | | 1.6 | 0.9 | | | |
| AD ± | 0.01 | 0.01 | | | | | | | | | 0.01 | | | | |
| October | | 1.62 | 1.63 | | 1.44 | | 1.25 | | | | 1.53 | 1.46 | | | |
| AD ± | | 0.00 | 0.07 | | | | | | | | 0.04 | | | | |
| November | | | | 1.0 | 1.33 | | | | | | 1.11 | | | | |
| AD ± | | | | 0.10 | | | | | | | 0.16 | | | | |
| December | | | | 1.43 | | | | | | | | | | | |
| AD ± | | | | 0.07 | | | | | | | | | | | |
| January | | | 1.45 | 1.58 | 1.36 | 1.40 | | 1.66 | | | 1.53 | 0.79 | | | |
| AD ± | | | 0.02 | 0.04 | | 0.02 | | | | | 0.03 | 0.12 | | | |
| M | 1.9 | 1.8 | 1.6 | 1.5 | 1.4 | 1.4 | 1.3 | 1.4 | 1.4 | 1.0 | 1.6 | 0.9 | 0.9 | 0.3 | 0.2 |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | |

TABLE 2.—*310 to 370 millimicrons*—Continued.

C. TOTAL DAY.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | < 2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 1.7 | 1.5 | 1.1 | | 1.2 | | | | | 1.4 | 0.9 | 0.6 | | |
| AD ± | | 0.02 | 0.00 | | | 0.07 | | | | | 0.08 | 0.05 | 0.07 | | |
| March | 1.9 | 1.7 | 1.7 | 1.6 | 1.3 | 1.2 | 1.4 | | 1.2 | 0.9 | 1.5 | 0.8 | 0.5 | | |
| AD ± | 0.04 | 0.03 | 0.02 | 0.04 | 0.06 | 0.07 | 0.08 | | 0.10 | 0.03 | 0.03 | 0.04 | 0.03 | | |
| April | 1.8 | 1.7 | 1.6 | 1.5 | 1.4 | 1.2 | 1.2 | 1.1 | | | 1.5 | 1.9 | | | |
| AD ± | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.05 | 0.16 | 0.06 | | | 0.05 | 0.07 | | | |
| May | 2.1 | 1.9 | 1.7 | 1.8 | 1.2 | | | | | | 1.8 | 0.9 | 0.8 | | |
| AD ± | 0.04 | 0.01 | 0.02 | 0.03 | 0.01 | | | | | | 0.04 | 0.02 | 0.07 | | |
| June | 2.0 | 1.9 | 1.7 | 1.6 | 1.6 | | | | | | 1.7 | | | | |
| AD ± | 0.03 | 0.05 | 0.05 | 0.04 | 0.08 | | | | | | 0.03 | | | | |
| July | | | 1.8 | | | 1.4 | 1.5 | | | | 1.5 | | | | |
| AD ± | | | 0.07 | | | 0.04 | 0.06 | | | | 0.12 | | | | |
| August | 1.8 | 1.8 | 1.6 | | | 1.4 | 1.3 | | | | 0.8 | 0.8 | | | |
| AD ± | 0.07 | 0.07 | 0.07 | | | 0.07 | 0.10 | | | | 0.10 | 0.08 | | | |
| September | 1.8 | 1.7 | | | | | | | | | 1.6 | 0.9 | | | |
| AD ± | 0.02 | 0.02 | | | | | | | | | 0.02 | | | | |
| October | | 1.64 | 1.63 | | 1.39 | | | | | | 0.91 | | | | |
| AD ± | | 0.08 | 0.03 | | 0.04 | | | | | | 0.04 | | | | |
| November | | | | 1.24 | 1.33 | | | | | | | | | | |
| AD ± | | | | 0.10 | 0. 00 | | | | | | | | | | |
| December | | | | 1.46 | | | | | | | | | | | |
| AD ± | | | | 0.02 | | | | | | | | | | | |
| January | | | 1.50 | 1.74 | 1.37 | 1.28 | | 1.28 | | | 1.41 | 0.70 | | | |
| AD ± | | | 0.06 | 0.06 | 0.04 | 0.04 | | 0.01 | | | 0.05 | 0.08 | | | |
| M | 1.9 | 1.8 | 1.6 | 1.5 | 1.4 | 1.4 | 1.4 | 1.2 | 1.2 | 0.9 | 1.4 | 1.0 | 0.6 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | | | 0.1 | 0.1 | 0.1 | | |

TABLE 3.—*370 to 400 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | < 2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 2.9 | 3.0 | 3.0 | | 2.4 | | 1.9 | | | 2.8 | 1.9 | 1.5 | | |
| AD ± | | 0.1 | | | | | | 0.2 | | | 0.2 | 0.1 | 0.0 | | |
| March | 3.4 | 3.0 | 2.8 | 2.9 | 2.4 | 2.4 | 2.2 | 2.4 | 2.5 | 2.1 | 2.7 | 1.8 | 1.5 | | |
| AD ± | | 0.1 | 0.0 | 0.1 | 0.1 | 0.1 | | | 0.0 | | 0.1 | 0.0 | | | |
| April | 3.3 | 3.0 | 3.0 | 2.0 | 2.7 | 2.6 | 2.2 | 2.4 | 2.2 | 2.3 | 2.8 | 2.1 | | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | | 0.1 | 0.1 | 0.1 | 0.2 | | | |
| May | 3.4 | 3.4 | 3.3 | 2.7 | 3.0 | 2.9 | | 2.4 | 2.6 | | 3.2 | 2.2 | 2.2 | | |
| AD ± | 0.1 | 0.1 | | | | 0.1 | | | 0.0 | | 0.1 | 0.1 | | | |
| June | 3.2 | 3.3 | 3.2 | 3.1 | 3.2 | 2.8 | | 2.8 | 2.4 | | 2.7 | 2.2 | | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | | 0.0 | | 0.0 | 0.0 | | 0.1 | 0.1 | | | |
| July | | | 3.3 | | 3.4 | 2.9 | 2.9 | | 2.7 | 3.1 | 3.3 | 2.2 | | | |
| AD ± | | | 0.1 | | 0.1 | | | | | | 0.2 | 0.2 | | | |
| August | 3.4 | 3.2 | 3.2 | | | 2.6 | 2.7 | | 2.5 | 2.6 | 3.1 | 2.0 | | | |
| AD ± | 0.1 | 0.1 | 0.1 | | | | 0.1 | | | | 0.1 | 0.1 | | | |
| September | 3.4 | 3.4 | 3.2 | 2.7 | | | 2.8 | | | | 3.2 | 2.6 | | | |
| AD ± | 0.1 | 0.0 | 0.1 | | | | 0.1 | | | | 0.1 | | | | |
| October | | 3.3 | 3.3 | 3.0 | 3.0 | | | | | | 3.2 | | | | |
| AD ± | | 0.1 | 0.1 | 0.1 | | | | | | | 0.1 | | | | |
| November | | | 2.9 | 2.9 | 3.2 | 2.5 | 2.6 | 2.0 | | 2.7 | 2.6 | 2.4 | | | |
| AD ± | | | | 0.1 | | | 0.1 | 0.0 | | | 0.1 | 0.1 | | | |
| December | | | | 2.7 | 3.1 | 3.0 | 2.7 | 2.4 | | 2.3 | 2.7 | 1.9 | | | |
| AD ± | | | | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | | | 0.1 | 0.1 | | | |
| January | | | 2.8 | 2.7 | 2.8 | 2.7 | 2.5 | 2.5 | | 2.3 | 2.7 | 1.7 | | | |
| AD ± | | | 0.1 | 0.2 | 0.1 | 0.1 | | 0.1 | | 0.1 | 0.1 | 0.2 | | | |
| M | 3.3 | 3.2 | 3.1 | 2.6 | 2.9 | 2.7 | 2.6 | 2.4 | 2.5 | 2.5 | 2.9 | 2.1 | 1.7 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | | |

TABLE 3.—*370 to 400 millimicrons*—Continued.

B. AFTERNOON SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 3.0 | 2.6 | | 2.5 | 2.4 | | | 1.9 | | 2.6 | 1.9 | 1.3 | 0.6 | |
| AD ± | | 0.1 | | | | | | | | | 0.2 | | | | |
| March | 3.2 | 3.1 | 2.8 | 2.8 | 2.8 | 2.5 | 2.5 | | 1.9 | 2.1 | 2.9 | 0.9 | 1.5 | 0.6 | |
| AD ± | | 0.1 | 0.1 | 0.1 | 0.0 | | | | | | 0.1 | 0.0 | 0.0 | 0.0 | |
| April | 3.2 | 2.9 | 2.6 | 2.5 | 2.8 | 2.2 | 1.9 | 2.5 | | | 2.8 | 1.7 | 1.3 | 0.8 | 0.1 |
| AD ± | 0.1 | 0.1 | | 0.2 | 0.2 | | | 0.1 | | | 0.1 | 0.1 | 0.1 | 0.1 | |
| May | 3.3 | 3.3 | 3.2 | 2.7 | 2.8 | | 2.8 | | | | 3.1 | 2.0 | 1.4 | 0.8 | |
| AD ± | 0.1 | 0.1 | 0.0 | 0.0 | | | | | | | 0.1 | 0.0 | | | |
| June | 3.4 | 3.4 | 3.3 | 3.2 | 2.8 | | 2.8 | | | 2.6 | 3.2 | | 2.1 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | | 0.1 | | | | 0.1 | | | | |
| July | | | 3.6 | | | 3.0 | 3.1 | | | | 3.3 | | | | |
| AD ± | | | 0.1 | | | | | | | | 0.1 | | | | |
| August | 3.5 | 3.2 | 3.5 | 3.1 | 2.9 | 2.9 | 2.8 | 2.6 | | | 3.2 | 2.2 | 1.2 | 1.3 | |
| AD ± | 0.0 | 0.1 | 0.1 | 0.0 | | 0.0 | | 0.1 | | | 0.1 | 0.0 | 0.2 | 0.2 | |
| September | 3.6 | 3.4 | | | | 2.6 | | | 2.3 | | 3.1 | 2.0 | | | |
| AD ± | 0.1 | 0.1 | | | | | | | | | 0.1 | | | | |
| October | | 3.3 | 3.4 | | 3.2 | | 2.4 | | | | 3.2 | 1.9 | | | |
| AD ± | | 0.1 | 0.1 | | | | | | | | 0.1 | | | | |
| November | | | | 2.4 | 2.8 | | | | | | 2.5 | | | | |
| AD ± | | | | 0.3 | | | | | | | 0.2 | | | | |
| December | | | | 2.8 | | | | | | | | | | | |
| AD ± | | | | 0.1 | | | | | | | | | | | |
| January | | | 2.7 | 2.6 | 3.1 | 2.6 | | 1.3 | | | 2.5 | 1.5 | | | |
| AD ± | | | 0.1 | 0.1 | | 0.0 | | | | | 0.1 | 0.2 | | | |
| M | 3.4 | 3.2 | 3.1 | 2.8 | 2.9 | 2.6 | 2.6 | 2.1 | 2.0 | 2.4 | 2.9 | 1.8 | 1.5 | 0.8 | 0.1 |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | |

C. TOTAL DAY.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 3.0 | 2.8 | | | 2.4 | | | | | 2.3 | 1.9 | 1.5 | | |
| AD ± | | 0.1 | 0.1 | | | 0.0 | | | | | 0.1 | 0.1 | 0.2 | | |
| March | 3.3 | 3.1 | 2.8 | 2.8 | 2.6 | 2.4 | 2.4 | | 2.3 | 2.1 | 2.8 | 1.9 | 1.5 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | | 0.2 | 0.0 | 0.0 | 0.1 | 0.1 | | |
| April | 3.2 | 3.0 | 2.9 | 2.7 | 2.7 | 2.6 | 2.6 | 2.5 | | | 2.8 | 1.9 | | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | | | 0.1 | 0.07 | | | |
| May | 3.4 | 3.4 | 3.2 | 2.7 | 2.9 | | | | | | 3.2 | 2.1 | 1.8 | | |
| AD ± | 0.1 | 0.1 | 0.0 | 0.0 | 0.1 | | | | | | 0.1 | 0.1 | 0.3 | | |
| June | 3.3 | 3.3 | 3.3 | 3.2 | 2.9 | | | | | | 2.9 | | | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | | | | | | 0.1 | | | | |
| July | | | 3.4 | | | 3.0 | 3.0 | | | | 2.7 | | | | |
| AD ± | | | 0.1 | | | 0.1 | 0.1 | | | | 0.3 | | | | |
| August | 3.4 | 3.2 | 3.4 | | | 2.8 | 2.7 | | | | 2.0 | 2.0 | | | |
| AD ± | 0.1 | 0.1 | 0.1 | | | 0.1 | 0.1 | | | | 0.1 | 0.1 | | | |
| September | 3.4 | 3.4 | | | | | | | | | 3.2 | 2.3 | | | |
| AD ± | 0.1 | 0.1 | | | | | | | | | 0.1 | 0.2 | | | |
| October | | 3.3 | 3.3 | | 3.1 | | | | | | 1.9 | | | | |
| AD ± | | 0.1 | 0.1 | | 0.1 | | | | | | 0.1 | | | | |
| November | | | | 2.6 | 3.0 | | | | | | | | | | |
| AD ± | | | | 0.2 | 0.1 | | | | | | | | | | |
| December | | | | 2.6 | | | | | | | | | | | |
| AD ± | | | | 0.1 | | | | | | | | | | | |
| January | | | 2.7 | 2.7 | 2.8 | 2.6 | | 2.1 | | | 2.6 | 1.6 | | | |
| AD ± | | | 0.1 | 0.1 | 0.1 | 0.1 | | 0.5 | | | 0.1 | 0.2 | | | |
| M | 3.4 | 3.2 | 3.1 | 2.6 | 2.9 | 2.6 | 2.7 | 2.3 | 2.3 | 2.1 | 2.6 | 2.0 | 1.6 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.0 | 0.1 | 0.1 | 0.1 | | |

TABLE 4.—*400 to 460 millimicrons.*

[Percentage of total energy.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 8.7 | 8.1 | 7.8 | | 7.7 | | 7.1 | | | 7.8 | 7.3 | 6.8 | | |
| AD ± | | 0.1 | | | | | | 0.4 | | | 0.3 | 0.4 | 0.4 | | |
| March | 9.2 | 8.8 | 8.2 | 8.4 | 8.4 | 8.2 | 8.2 | 8.4 | 7.4 | 7.3 | 8.4 | 7.4 | 6.4 | | |
| AD ± | | 0.2 | 0.5 | 0.2 | 0.1 | 0.2 | | | 0.1 | | 0.2 | 0.2 | | | |
| April | 8.9 | 9.0 | 8.4 | 8.6 | 8.4 | 7.8 | 8.2 | 8.9 | 7.9 | 7.7 | 8.5 | 6.8 | | | |
| AD ± | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.1 | 0.5 | | 0.1 | 0.2 | 0.2 | 0.2 | | | |
| May | 9.4 | 9.2 | 9.0 | 9.7 | 8.8 | 9.0 | | 7.6 | 8.5 | | 9.2 | 8.0 | 9.3 | | |
| AD ± | 0.1 | 0.2 | | 0.0 | | 0.6 | | | 0.1 | | 0.2 | 0.3 | | | |
| June | 9.4 | 9.2 | 9.0 | 9.3 | 8.8 | 8.4 | | 8.0 | 7.8 | | 9.2 | 7.5 | | | |
| AD ± | 0.1 | 0.2 | 0.2 | 0.3 | | 0.0 | | 0.1 | 0.1 | | 0.1 | 0.2 | | | |
| July | | | 8.0 | | 8.6 | 8.3 | 8.2 | | | 7.8 | 8.2 | 7.9 | | | |
| AD ± | | | 0.5 | | 0.2 | | | | | | 0.3 | 0.6 | | | |
| August | 9.5 | 9.2 | 8.7 | | | 8.0 | 8.8 | | 8.1 | 8.3 | 9.0 | 7.7 | | | |
| AD ± | 0.1 | 0.2 | 0.6 | | | | 0.1 | | | | 0.2 | 0.2 | | | |
| September | 10.5 | 9.6 | 9.5 | 8.9 | | | 9.2 | | | | 9.4 | 8.0 | | | |
| AD ± | 0.1 | 0.2 | 0.1 | | | | 0.6 | | | | 0.2 | | | | |
| October | | 9.3 | 9.3 | 8.8 | 8.0 | | | | | | 9.1 | | | | |
| AD ± | | 0.1 | 0.2 | 0.1 | | | | | | | 0.1 | | | | |
| November | | | 8.8 | 8.8 | 8.6 | 6.8 | 8.3 | 8.2 | | | 8.3 | 8.9 | | | |
| AD ± | | | | 0.3 | | | | 0.3 | | | 0.3 | 0.3 | | | |
| December | | | | 9.3 | 9.2 | 9.5 | 9.2 | 8.3 | | 9.1 | 9.1 | 8.2 | | | |
| AD ± | | | | 0.2 | 0.1 | 0.4 | 0.2 | 0.2 | | | 0.2 | 0.2 | | | |
| January | | | 8.8 | 8.4 | 7.7 | 8.2 | 7.9 | 8.6 | | 7.6 | 8.2 | 7.0 | | | |
| AD ± | | | 0.5 | 0.3 | 0.5 | 0.2 | | 0.6 | | 0.1 | 0.4 | 0.3 | | | |
| M | 9.5 | 9.1 | 8.7 | 8.8 | 8.6 | 8.2 | 8.4 | 8.1 | 7.9 | 8.0 | 8.7 | 7.7 | 7.5 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | | |

B. AFTERNOON SUN.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 9.6 | 7.8 | | 8.8 | 8.1 | | | 6.7 | | 8.5 | 6.7 | 6.4 | 3.9 | |
| AD ± | | 0.9 | | | | | | | | | 0.8 | | | | |
| March | 8.8 | 9.2 | 8.9 | 8.7 | 8.4 | 8.4 | 9.4 | | 7.1 | 7.2 | 8.8 | 7.5 | 6.6 | 5.1 | |
| AD ± | | 0.2 | 0.4 | 0.1 | 0.2 | | | | | | 0.5 | 0.1 | 0.1 | 0.1 | |
| April | 9.1 | 8.6 | 7.5 | 8.2 | 7.8 | 8.7 | 6.3 | 7.5 | | | 8.7 | 7.8 | 5.5 | 4.6 | 1.7 |
| AD ± | 0.2 | 0.1 | | 0.2 | 0.1 | | | 0.1 | | | 0.2 | 0.6 | 0.5 | 0.5 | |
| May | 9.4 | 9.0 | 8.9 | 9.3 | 8.7 | | 9.0 | | | | 9.4 | 6.9 | 7.4 | 5.7 | |
| AD ± | 0.2 | 0.2 | 0.1 | 0.1 | | | | | | | 0.2 | 0.1 | | | |
| June | 9.1 | 9.4 | 9.4 | 9.4 | 9.1 | | 8.6 | | | 7.3 | 9.1 | | 7.4 | | |
| AD ± | 0.1 | 0.3 | 0.2 | 0.1 | 0.2 | | 0.1 | | | | 0.2 | | | | |
| July | | | 10.0 | | | 9.0 | 8.9 | | | | 9.5 | | | | |
| AD ± | | | 0.0 | | | | | | | | 0.2 | | | | |
| August | 9.5 | 9.3 | 9.5 | 9.4 | 10.0 | 8.8 | 7.1 | 8.8 | | | 9.2 | 6.9 | 7.4 | 6.0 | |
| AD ± | 0.2 | 0.3 | 0.2 | 0.2 | | 0.1 | | 0.1 | | | 0.2 | 0.2 | 0.3 | 0.2 | |
| September | 9.6 | 10.6 | | | | 8.5 | | | 8.2 | | 9.5 | 8.0 | | | |
| AD ± | 0.5 | 0.1 | | | | | | | | | 0.3 | | | | |
| October | | 9.7 | 9.4 | | 9.6 | | 9.6 | | | | 9.5 | 8.5 | | | |
| AD ± | | 0.1 | 0.1 | | | | | | | | 0.1 | | | | |
| November | | | | 8.7 | 8.5 | | | | | | 8.6 | | | | |
| AD ± | | | | 0.4 | | | | | | | 0.2 | | | | |
| December | | | | 9.2 | | | | | | | | | | | |
| AD ± | | | | 0.4 | | | | | | | | | | | |
| January | | | 8.3 | 9.2 | 7.8 | 8.8 | | 7.5 | | | 8.8 | 7.3 | | | |
| AD ± | | | 0.6 | 0.3 | | 0.3 | | | | | 0.3 | 0.3 | | | |
| M | 9.3 | 9.4 | 8.9 | 9.0 | 8.8 | 8.6 | 8.4 | 8.0 | 7.3 | 7.3 | 9.1 | 7.4 | 6.8 | 5.1 | 1.7 |
| AD ± | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.1 | 0.4 | 0.3 | 0.3 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | |

TABLE 4.—*400 to 460 millimicrons*—Continued.

C. TOTAL DAY.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 9.2 | 8.0 | | | 7.9 | | | | | 8.1 | 7.2 | 6.7 | | |
| AD ± | | 0.5 | 0.1 | | | 0.1 | | | | | 1.4 | 0.3 | 0.3 | | |
| March | 9.0 | 9.0 | 8.6 | 8.6 | 8.4 | 8.3 | 8.8 | | 7.8 | 7.3 | 8.6 | 7.5 | 6.5 | | |
| AD ± | 0.1 | 0.1 | 0.3 | 0.1 | 0.2 | 0.2 | 0.4 | | 0.3 | 0.0 | 0.1 | 0.1 | 0.1 | | |
| April | 8.9 | 8.9 | 8.3 | 8.4 | 8.2 | 8.0 | 7.7 | 8.0 | | | 8.5 | 7.4 | | | |
| AD ± | 0.1 | 0.2 | 0.2 | 0.3 | 0.2 | 0.1 | 0.4 | 0.1 | | | 0.2 | 0.4 | | | |
| May | 9.4 | 9.1 | 9.0 | 9.5 | 8.8 | | | | | | 9.1 | 7.6 | 8.4 | | |
| AD ± | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | | | | | | 0.2 | 0.2 | 0.3 | | |
| June | 9.5 | 9.3 | 9.2 | 9.4 | 9.0 | | | | | | 9.1 | | | | |
| AD ± | 0.1 | 0.2 | 0.2 | 0.2 | 0.4 | | | | | | 0.1 | | | | |
| July | | | 8.8 | | | 8.7 | 8.6 | | | | 8.6 | | | | |
| AD ± | | | 0.3 | | | 0.3 | 0.3 | | | | 0.3 | | | | |
| August | 9.5 | 9.3 | 9.2 | | | 8.5 | 8.2 | | | | 8.5 | 7.3 | | | |
| AD ± | 0.1 | 0.3 | 0.3 | | | 0.1 | 0.1 | | | | 0.2 | 0.2 | | | |
| September | 10.2 | 9.8 | | | | | | | | | 9.7 | 8.0 | | | |
| AD ± | 0.3 | 0.2 | | | | | | | | | 0.2 | | | | |
| October | | 9.4 | 9.3 | | 8.8 | | | | | | 7.8 | | | | |
| AD ± | | 0.1 | 0.2 | | 0.6 | | | | | | 0.3 | | | | |
| November | | | | 8.7 | 8.6 | | | | | | 8.4 | | | | |
| AD ± | | | | 0.3 | 0.0 | | | | | | 0.2 | | | | |
| December | | | | 9.3 | | | | | | | | | | | |
| AD ± | | | | 0.3 | | | | | | | | | | | |
| January | | | 8.6 | 8.9 | 7.7 | 8.4 | | 8.2 | | | 8.5 | 7.0 | | | |
| AD ± | | | 0.5 | 0.3 | 0.4 | 0.2 | | 0.3 | | | 0.4 | 0.3 | | | |
| M | 9.4 | 9.3 | 8.7 | 9.0 | 8.5 | 8.3 | 8.3 | 8.1 | 7.8 | 7.3 | 8.4 | 7.5 | 7.2 | | |
| AD ± | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.3 | 0.0 | 0.1 | 0.1 | 0.3 | | |

TABLE 5.—*290 to 310 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 0.41 | 0.43 | 0.23 | | 0.22 | | 0.22 | | | 0.27 | 0.18 | 0.11 | | |
| AD ± | | 0.02 | | | | | | 0.01 | | | 0.02 | 0.01 | 0.01 | | |
| March | 0.87 | 0.63 | 0.54 | 0.46 | 0.32 | 0.28 | 0.28 | 0.26 | 0.21 | 0.20 | 0.45 | 0.12 | 0.11 | | |
| AD ± | | 0.06 | 0.10 | 0.07 | 0.04 | 0.02 | | | 0.00 | | 0.06 | 0.01 | | | |
| April | 0.61 | 0.47 | 0.55 | 0.55 | 0.43 | 0.33 | 0.36 | 0.39 | 0.26 | 0.38 | 0.47 | 0.16 | | | |
| AD ± | 0.05 | 0.05 | 0.08 | 0.07 | 0.06 | 0.05 | 0.07 | | 0.02 | 0.04 | 0.05 | 0.01 | | | |
| May | 0.68 | 0.50 | 0.62 | 0.36 | 0.33 | 0.40 | | 0.36 | 0.29 | | 0.49 | 0.17 | 0.16 | | |
| AD ± | 0.05 | 0.06 | | 0.01 | | 0.03 | | | 0.04 | | 0.05 | 0.03 | | | |
| June | 0.66 | 0.51 | 0.43 | 0.40 | 0.32 | 0.39 | | 0.19 | 0.34 | | 0.48 | 0.18 | | | |
| AD ± | 0.05 | 0.07 | 0.09 | 0.06 | | 0.15 | | 0.02 | 0.01 | | 0.06 | 0.02 | | | |
| July | | | 0.45 | | 0.43 | 0.53 | 0.30 | | 0.23 | 0.15 | 0.38 | 0.18 | | | |
| AD ± | | | 0.09 | | 0.10 | | | | | | 0.15 | 0.05 | | | |
| August | 0.55 | 0.64 | 0.65 | | | 0.36 | 0.26 | | 0.22 | 0.16 | 0.48 | 0.18 | | | |
| AD ± | 0.06 | 0.10 | 0.11 | | | | 0.04 | | | | 0.09 | 0.04 | | | |
| September | 0.95 | 0.77 | 0.44 | 0.34 | | | 0.34 | | | | 0.65 | 0.11 | | | |
| AD ± | 0.04 | 0.08 | 0.15 | | | | 0.14 | | | | 0.09 | | | | |
| October | | 0.61 | 0.54 | 0.39 | 0.43 | | | | | | 0.53 | | | | |
| AD ± | | 0.06 | 0.06 | 0.04 | | | | | | | 0.06 | | | | |
| November | | | 0.63 | 0.51 | 0.62 | 0.26 | 0.57 | 0.26 | | 0.37 | 0.45 | 0.22 | | | |
| AD ± | | | | 0.05 | | | 0.03 | 0.06 | | 0.12 | 0.06 | 0.01 | | | |
| December | | | | 0.58 | 0.15 | 0.38 | 0.47 | 0.39 | | 0.49 | 0.45 | 0.20 | | | |
| AD ± | | | | 0.04 | 0.00 | 0.19 | 0.03 | 0.02 | | | 0.05 | 0.04 | | | |
| January | | | 0.38 | 0.39 | 0.45 | 0.41 | 0.47 | 0.45 | | 0.30 | 0.40 | 0.26 | | | |
| AD ± | | | 0.08 | 0.06 | 0.04 | 0.06 | | 0.02 | | 0.01 | 0.06 | 0.02 | | | |
| M | 0.72 | 0.57 | 0.51 | 0.42 | 0.38 | 0.36 | 0.40 | 0.31 | 0.26 | 0.30 | 0.46 | 0.18 | 0.13 | | |
| AD ± | 0.05 | 0.03 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.02 | 0.04 | 0.02 | 0.01 | 0.01 | | |

TABLE 5.—*290 to 310 millimicrons*—Continued.

B. AFTERNOON SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 0.43 | 0.34 | | 0.38 | 0.24 | | | 0.13 | | 0.33 | 0.12 | 0.10 | 0.02 | |
| AD ± | | 0.01 | | | | | | | | | 0.01 | | | | |
| March | 0.71 | 0.61 | 0.51 | 0.52 | 0.45 | 0.30 | 0.35 | | 0.21 | 0.43 | 0.52 | 0.18 | 0.11 | 0.07 | |
| AD ± | | 0.05 | 0.03 | 0.08 | 0.01 | | | | | | 0.03 | 0.03 | 0.00 | 0.03 | |
| April | 0.61 | 0.47 | 0.40 | 0.37 | 0.34 | 0.25 | 0.17 | 0.36 | | | 0.48 | 0.14 | 0.10 | 0.04 | 0.01 |
| AD ± | 0.07 | 0.06 | | 0.06 | 0.07 | | | 0.07 | | | 0.07 | 0.01 | 0.01 | 0.01 | |
| May | 0.63 | 0.68 | 0.54 | 0.36 | 0.56 | | 0.23 | | | | 0.56 | 0.26 | 0.08 | 0.04 | |
| AD ± | 0.08 | 0.07 | 0.02 | 0.01 | | | | | | | 0.05 | 0.03 | | | |
| June | 0.55 | 0.52 | 0.46 | 0.63 | 0.51 | | 0.57 | | | 0.32 | 0.52 | | 0.23 | | |
| AD ± | 0.05 | 0.08 | 0.10 | 0.10 | 0.09 | | 0.02 | | | | 0.08 | | | | |
| July | | | 0.67 | | | 0.21 | 0.24 | | | | 0.59 | | | | |
| AD ± | | | 0.38 | | | | | | | | 0.36 | | | | |
| August | 0.76 | 0.62 | 0.52 | 0.63 | 0.53 | 0.48 | 0.41 | 0.39 | | | 0.56 | 0.28 | 0.13 | 0.12 | |
| AD ± | 0.09 | 0.09 | 0.08 | 0.15 | | 0.09 | | 0.07 | | | 0.09 | 0.04 | 0.01 | 0.02 | |
| September | 0.81 | 0.75 | | | | 0.18 | | | 0.10 | | 0.57 | 0.11 | | | |
| AD ± | 0.03 | 0.04 | | | | | | | | | 0.04 | | | | |
| October | | 0.60 | 0.27 | | 0.12 | | 0.12 | | | | 0.30 | 0.17 | | | |
| AD ± | | 0.10 | 0.05 | | | | | | | | 0.07 | 0.06 | | | |
| November | | | | 0.30 | 0.44 | 0.64 | | | | | 0.42 | | | | |
| AD ± | | | | 0.05 | | | | | | | 0.05 | | | | |
| December | | | | 0.59 | | | | | | | | | | | |
| AD ± | | | | 0.03 | | | | | | | | | | | |
| January | | | 0.41 | 0.42 | 0.36 | 0.40 | | 0.35 | | | 0.40 | 0.28 | | | |
| AD ± | | | 0.07 | 0.07 | | 0.06 | | | | | 0.06 | 0.10 | | | |
| M | 0.68 | 0.58 | 0.46 | 0.48 | 0.41 | 0.34 | 0.30 | 0.36 | 0.15 | 0.38 | 0.48 | 0.19 | 0.13 | 0.06 | 0.01 |
| AD ± | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.05 | 0.04 | 0.01 | 0.02 | 0.04 | 0.03 | 0.02 | 0.02 | 0.01 | |

C. TOTAL DAY.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 0.42 | 0.39 | | | 0.23 | | | | | 0.31 | 0.16 | 0.11 | | |
| AD ± | | 0.01 | 0.04 | | | 0.01 | | | | | 0.03 | 0.01 | 0.01 | | |
| March | 0.79 | 0.62 | 0.53 | 0.49 | 0.37 | 0.29 | 0.31 | | 0.21 | 0.32 | 0.48 | 0.14 | 0.11 | | |
| AD ± | 0.06 | 0.04 | 0.02 | 0.05 | 0.03 | 0.02 | 0.03 | | 0.00 | 0.09 | 0.02 | 0.01 | 0.00 | | |
| April | 0.61 | 0.51 | 0.53 | 0.47 | 0.41 | 0.31 | 0.32 | 0.37 | | | 0.47 | 0.15 | 0.13 | | |
| AD ± | 0.04 | 0.04 | 0.07 | 0.05 | 0.05 | 0.04 | 0.06 | 0.04 | | | 0.02 | 0.01 | 0.03 | | |
| May | 0.67 | 0.57 | 0.57 | 0.35 | 0.45 | | | | | | 0.54 | 0.24 | 0.12 | | |
| AD ± | 0.04 | 0.06 | 0.02 | 0.01 | 0.09 | | | | | | 0.03 | 0.02 | 0.04 | | |
| June | 0.63 | 0.51 | 0.44 | 0.50 | 0.45 | | | | | | 0.50 | | | | |
| AD ± | 0.04 | 0.05 | 0.06 | 0.06 | 0.07 | | | | | | 0.05 | | | | |
| July | | | 0.37 | | 0.43 | 0.37 | 0.27 | | | | 0.33 | | | | |
| AD ± | | | 0.05 | | 0.10 | 0.11 | 0.02 | | | | 0.06 | | | | |
| August | 0.61 | 0.62 | 0.56 | | | 0.44 | 0.26 | 0.39 | | | 0.52 | 0.22 | 0.13 | | |
| AD ± | 0.05 | 0.07 | 0.07 | | | 0.06 | 0.04 | 0.07 | | | 0.06 | 0.03 | 0.01 | | |
| September | 0.90 | 0.76 | | | | | | | | | 0.62 | 0.11 | | | |
| AD ± | 0.04 | 0.07 | | | | | | | | | 0.08 | | | | |
| October | | 0.61 | 0.41 | | 0.28 | | | | | | 0.44 | | | | |
| AD ± | | 0.07 | 0.06 | | 0.11 | | | | | | 0.07 | | | | |
| November | | | | 0.43 | 0.54 | 0.45 | | | | | | | | | |
| AD ± | | | | 0.05 | 0.07 | | | | | | | | | | |
| December | | | | 0.58 | | | | | | | | | | | |
| AD ± | | | | 0.04 | | | | | | | | | | | |
| January | | | 0.39 | 0.41 | 0.41 | 0.60 | | 0.40 | | | 0.40 | 0.27 | | | |
| AD ± | | | 0.08 | 0.07 | 0.04 | 0.06 | | 0.01 | | | 0.06 | 0.05 | | | |
| M | 0.70 | 0.58 | 0.47 | 0.46 | 0.42 | 0.34 | 0.29 | 0.39 | 0.21 | 0.32 | 0.43 | 0.21 | 0.12 | | |
| AD ± | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.04 | 0.01 | 0.01 | | | 0.03 | 0.02 | 0.01 | | |

TABLE 6.—*310 to 370 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 13.8 | 11.8 | 7.8 | | 7.3 | | 7.6 | | | 9.8 | 8.3 | 4.3 | | |
| AD ± | | 0.2 | | | | | | 1.1 | | | 0.3 | 1.0 | 0.8 | | |
| March | 16.0 | 14.3 | 13.0 | 11.2 | 10.4 | 7.9 | 11.0 | 8.1 | 7.3 | 6.0 | 11.3 | 5.6 | 2.9 | | |
| AD ± | | 0.5 | 1.1 | 0.5 | 0.4 | 0.2 | | | 1.1 | | 0.5 | 0.6 | | | |
| April | 15.8 | 14.8 | 13.0 | 12.9 | 11.3 | 9.6 | 10.5 | 10.6 | 7.6 | 7.3 | 12.6 | 5.5 | | | |
| AD ± | 0.4 | 0.4 | 0.7 | 0.6 | 0.5 | 0.8 | 1.9 | | 0.5 | 1.4 | 1.0 | 0.6 | | | |
| May | 16.9 | 15.5 | 12.4 | 11.7 | 9.2 | 10.5 | | 7.6 | 8.4 | | 13.0 | 5.8 | 6.0 | | |
| AD ± | 0.6 | 0.3 | | 1.9 | | 1.3 | | | 0.1 | | 0.7 | 0.4 | | | |
| June | 17.2 | 15.2 | 13.6 | 12.7 | 11.6 | 9.5 | | 9.7 | 7.9 | | 13.8 | 5.7 | | | |
| AD ± | 0.4 | 0.3 | 0.6 | 0.5 | | 0.9 | | 0.8 | 1.3 | | 0.5 | 0.5 | | | |
| July | | | 13.8 | | 12.2 | 10.8 | 11.1 | | 7.4 | 7.9 | 11.8 | 5.9 | | | |
| AD ± | | | 0.6 | | 0.8 | | | | | | 0.7 | 0.6 | | | |
| August | 15.4 | 13.6 | 10.9 | | | 7.7 | 8.0 | | 9.0 | 6.6 | 12.3 | 4.1 | | | |
| AD ± | 0.4 | 0.2 | 1.3 | | | | 0.2 | | | | 0.4 | 0.4 | | | |
| September | 17.1 | 15.7 | 13.4 | 14.1 | | | 10.1 | | | | 14.7 | 6.7 | | | |
| AD ± | 0.4 | 0.3 | 0.6 | | | | 0.5 | | | | 0.5 | | | | |
| October | | 13.9 | 13.0 | 10.9 | 10.1 | | | | | | 12.9 | | | | |
| AD ± | | 0.7 | 0.9 | 0.8 | | | | | | | 0.7 | | | | |
| November | | | 12.1 | 8.4 | 11.2 | 5.7 | 11.3 | 3.9 | | 9.6 | 8.7 | 6.6 | | | |
| AD ± | | | | 0.9 | | | 0.1 | 0.0 | | 1.4 | 0.6 | 0.7 | | | |
| December | | | | 11.8 | 8.0 | 7.6 | 10.0 | 8.4 | | 6.9 | 9.3 | 4.9 | | | |
| AD ± | | | | 0.7 | 0.1 | 3.0 | 0.2 | 0.2 | | | 0.7 | 0.5 | | | |
| January | | | 12.9 | 12.7 | 10.3 | 9.0 | 8.4 | 8.1 | | 6.3 | 10.2 | 12.2 | | | |
| AD ± | | | 1.1 | 0.9 | 0.7 | 0.7 | | 1.0 | | 0.9 | 0.9 | 0.6 | | | |
| M | 16.4 | 14.6 | 12.7 | 11.4 | 10.5 | 8.6 | 10.1 | 8.0 | 7.9 | 7.2 | 11.7 | 6.1 | 4.4 | | |
| AD ± | 0.3 | 0.3 | 0.2 | 0.5 | 0.3 | 0.4 | 0.3 | 0.5 | 0.2 | 0.3 | 0.4 | 0.4 | 0.7 | | |

B. AFTERNOON SUN.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | ------ | 13.5 | 11.0 | ------ | 9.9 | 8.9 | ------ | ------ | 7.2 | ------ | 10.7 | 5.0 | 2.0 | 0.4 | ------ |
| AD ± | ------ | 0.5 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.5 | ------ | ------ | ------ | ------ |
| March | 14.9 | 15.1 | 14.3 | 13.5 | 11.2 | 11.7 | 9.8 | ------ | 11.5 | 7.4 | 13.5 | 5.5 | 3.2 | 1.5 | ------ |
| AD ± | ------ | 0.4 | 0.2 | 0.5 | 1.5 | ------ | ------ | ------ | ------ | ------ | 0.6 | 0.3 | 0.1 | 0.4 | ------ |
| April | 15.8 | 14.4 | 11.6 | 11.5 | 10.2 | 7.8 | 5.5 | 8.1 | ------ | ------ | 12.7 | 5.2 | 3.8 | 1.1 | 0.4 |
| AD ± | 0.4 | 0.2 | ------ | 0.3 | 0.2 | ------ | ------ | 0.7 | ------ | ------ | 0.3 | 0.5 | 0.6 | 0.1 | ------ |
| May | 16.0 | 15.2 | 11.8 | 12.8 | 10.1 | ------ | 10.6 | ------ | ------ | ------ | 14.3 | 5.7 | 3.5 | 2.2 | ------ |
| AD ± | 0.6 | 0.4 | 1.1 | 1.7 | ------ | ------ | ------ | ------ | ------ | ------ | 0.8 | 0.1 | ------ | ------ | ------ |
| June | 16.7 | 15.6 | 13.2 | 14.1 | 13.8 | ------ | 11.6 | ------ | ------ | 7.1 | 14.1 | ------ | 4.2 | ------ | ------ |
| AD ± | 0.7 | 1.0 | 1.1 | 0.1 | 0.9 | ------ | 0.1 | ------ | ------ | ------ | 0.7 | ------ | ------ | ------ | ------ |
| July | ------ | ------ | 8.7 | ------ | ------ | 5.6 | 12.5 | ------ | ------ | ------ | 8.9 | ------ | ------ | ------ | ------ |
| AD ± | ------ | ------ | 1.4 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 1.4 | ------ | ------ | ------ | ------ |
| August | 14.1 | 15.2 | 12.9 | 12.3 | 11.6 | 14.4 | 8.0 | 11.6 | ------ | ------ | 12.4 | 8.0 | 3.8 | 1.8 | ------ |
| AD ± | 0.6 | 0.5 | 1.1 | 1.1 | ------ | 0.7 | ------ | 0.6 | ------ | ------ | 0.7 | 1.8 | 0.4 | 0.2 | ------ |
| September | 16.8 | 14.8 | ------ | ------ | ------ | 9.5 | ------ | ------ | 9.9 | ------ | 13.8 | 6.6 | ------ | ------ | ------ |
| AD ± | 0.1 | 0.4 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 0.3 | ------ | ------ | ------ | ------ |
| October | ------ | 12.2 | 6.3 | ------ | 3.5 | ------ | 3.0 | ------ | ------ | ------ | 6.8 | 3.6 | ------ | ------ | ------ |
| AD ± | ------ | 2.0 | 1.8 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | 1.8 | 1.1 | ------ | ------ | ------ |
| November | ------ | ------ | ------ | 6.6 | 8.9 | ------ | ------ | ------ | ------ | ------ | 7.3 | ------ | ------ | ------ | ------ |
| AD ± | ------ | ------ | ------ | 0.7 | ------ | ------ | ------ | ------ | ------ | ------ | 0.7 | ------ | ------ | ------ | ------ |
| December | ------ | ------ | ------ | 11.1 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| AD ± | ------ | ------ | ------ | 0.1 | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ | ------ |
| January | ------ | ------ | 12.1 | 12.9 | 11.8 | 11.3 | ------ | 12.6 | ------ | ------ | 12.4 | 5.5 | ------ | ------ | ------ |
| AD ± | ------ | ------ | 0.6 | 0.5 | ------ | 0.2 | ------ | ------ | ------ | ------ | 0.5 | 1.1 | ------ | ------ | ------ |
| M | 15.4 | 14.4 | 11.3 | 11.6 | 9.0 | 10.2 | 8.8 | 10.8 | 9.5 | 7.3 | 11.5 | 5.6 | 3.4 | 1.4 | 0.4 |
| AD ± | 0.4 | 0.3 | 0.5 | 0.5 | 0.9 | 0.9 | 0.9 | 1.1 | 0.9 | 0.1 | 0.7 | 0.2 | 0.2 | 0.3 | ------ |

TABLE 6.—*310 to 370 millimicrons*—Continued.

C. TOTAL DAY.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 13.5 | 11.4 | | | 8.1 | | | | | 10.0 | 6.2 | 3.0 | | |
| AD ± | | 0.3 | 0.3 | | | 0.6 | | | | | 0.7 | 0.7 | 0.6 | 1.0 | |
| March | 15.5 | 14.8 | 13.6 | 12.4 | 10.7 | 8.9 | 10.4 | | 8.7 | 6.7 | 12.4 | 5.6 | 3.1 | | |
| AD ± | 0.4 | 0.4 | 0.5 | 0.5 | 0.6 | 0.8 | 0.4 | | 0.8 | 0.5 | 0.4 | 0.4 | 0.1 | | |
| April | 15.8 | 14.6 | 12.9 | 12.3 | 10.9 | 9.3 | 9.2 | 8.9 | | | 12.6 | 5.5 | | | |
| AD ± | 0.3 | 0.3 | 0.6 | 0.3 | 0.4 | 0.7 | 1.5 | 0.7 | | | 0.2 | 0.4 | | | |
| May | 16.6 | 15.4 | 12.0 | 12.3 | 9.7 | | | | | | 13.7 | 5.8 | 4.8 | | |
| AD ± | 0.4 | 0.2 | 0.7 | 1.3 | 0.4 | | | | | | 0.5 | 0.1 | 0.1 | | |
| June | 17.1 | 15.4 | 13.4 | 13.3 | 13.1 | | | | | | 13.9 | | | | |
| AD ± | 0.4 | 0.4 | 0.6 | 0.3 | 0.5 | | | | | | 0.5 | | | | |
| July | | | 12.3 | | | 8.2 | 11.8 | | | | 10.9 | | | | |
| AD ± | | | 1.4 | | | 1.9 | 0.5 | | | | 1.2 | | | | |
| August | 14.9 | 14.5 | 12.2 | | | 12.2 | 8.0 | 11.6 | | | 12.7 | 5.2 | | | |
| AD ± | 0.4 | 0.3 | 0.8 | | | 2.4 | 0.2 | 0.8 | | | 0.6 | 0.5 | | | |
| September | 16.8 | 15.4 | | | | | | | | | 14.4 | 6.7 | | | |
| AD ± | 0.3 | 0.4 | | | | | | | | | 0.5 | 0.1 | | | |
| October | | 13.5 | 10.3 | | 6.8 | | | | | | 10.6 | | | | |
| AD ± | | 0.9 | 1.2 | | 2.4 | | | | | | 1.0 | | | | |
| November | | | | 7.5 | 10.1 | | | | | | | | | | |
| AD ± | | | | 0.8 | 0.9 | | | | | | | | | | |
| December | | | | 11.6 | | | | | | | | | | | |
| AD ± | | | | 0.7 | | | | | | | | | | | |
| January | | | 12.5 | 12.7 | 10.6 | 9.7 | | 10.3 | | | 11.1 | 4.8 | | | |
| AD ± | | | 0.9 | 0.6 | 0.7 | 0.6 | | 1.0 | | | 0.8 | 0.8 | | | |
| M | 16.1 | 14.6 | 12.3 | 11.7 | 10.3 | 9.4 | 9.9 | 10.3 | 8.7 | 6.7 | 12.2 | 5.7 | 3.6 | 1.0 | |
| AD ± | 0.3 | 0.2 | 0.2 | 0.5 | 0.5 | 0.4 | 0.6 | 1.0 | 0.8 | 0.8 | 0.4 | 0.2 | 0.5 | | |

TABLE 7.—*370 to 400 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 24.0 | 23.9 | 21.2 | | 16.3 | | 13.1 | | | 18.6 | 13.0 | 10.5 | | |
| AD ± | | 0.6 | | | | | | 2.5 | | | 1.7 | 1.2 | 1.9 | | |
| March | 30.1 | 26.7 | 26.5 | 21.8 | 18.3 | 16.6 | 16.9 | 18.0 | 17.4 | 14.3 | 22.0 | 12.4 | 9.5 | | |
| AD ± | | 1.5 | 4.1 | 0.6 | 0.6 | 1.2 | | | 0.9 | | 1.5 | 0.1 | | | |
| April | 29.1 | 25.8 | 24.1 | 23.5 | 21.4 | 20.2 | 17.7 | 19.8 | 18.0 | 16.6 | 23.6 | 14.2 | | | |
| AD ± | 0.7 | 1.0 | 1.3 | 1.5 | 1.0 | 0.7 | 0.5 | | 1.2 | 3.5 | 1.0 | 2.5 | | | |
| May | 27.6 | 27.6 | 24.9 | 12.7 | 25.6 | 20.8 | | 16.4 | 19.9 | | 25.0 | 13.3 | 15.4 | | |
| AD ± | 0.7 | 0.5 | | | | 2.0 | | | 0.2 | | 0.8 | 0.6 | | | |
| June | 27.3 | 27.8 | 25.3 | 25.4 | 26.2 | 20.5 | | 25.1 | 16.6 | | 25.6 | 14.9 | | | |
| AD ± | 0.9 | 0.7 | 0.4 | 0.5 | | 1.0 | | 1.1 | 1.4 | | 0.8 | 1.0 | | | |
| July | | | 27.5 | | 27.3 | 23.9 | 34.4 | | 19.9 | 17.2 | 26.5 | 14.4 | | | |
| AD ± | | | 1.5 | | 0.2 | | | | | | 1.0 | 1.1 | | | |
| August | 28.5 | 24.9 | 23.4 | | | 17.0 | 16.1 | | 20.2 | 11.5 | 25.8 | 11.1 | | | |
| AD ± | 0.6 | 0.6 | 1.6 | | | | 0.4 | | | | 0.7 | 0.3 | | | |
| September | 30.9 | 30.5 | 26.2 | 22.6 | | | 22.1 | | | | 27.9 | 17.7 | | | |
| AD ± | 0.4 | 0.1 | 0.8 | | | | 0.4 | | | | 0.3 | | | | |
| October | | 27.7 | 26.5 | 21.6 | 21.5 | | | | | | 25.7 | | | | |
| AD ± | | 1.5 | 1.0 | 1.4 | | | | | | | 0.5 | | | | |
| November | | | 22.7 | 16.2 | 26.8 | 15.0 | 23.7 | 10.2 | | 20.7 | 18.7 | 15.3 | | | |
| AD ± | | | | 1.0 | | | 0.1 | 1.2 | | 2.2 | 1.1 | 1.6 | | | |
| December | | | | 19.9 | 8.3 | 14.5 | 20.6 | 21.2 | | 17.1 | 18.1 | 12.8 | | | |
| AD ± | | | | 1.4 | 0.0 | 5.1 | 0.3 | 2.6 | | | 1.9 | 0.6 | | | |
| January | | | 23.4 | 20.5 | 21.2 | 19.1 | 18.5 | 18.3 | | 15.9 | 17.4 | 12.2 | | | |
| AD ± | | | 0.6 | 1.3 | 1.1 | 1.6 | | 1.0 | | 2.1 | 1.1 | 1.3 | | | |
| M | 28.9 | 27.0 | 24.9 | 20.5 | 21.8 | 18.4 | 21.2 | 17.8 | 18.7 | 15.9 | 23.0 | 13.7 | 11.8 | | |
| AD ± | 0.6 | 0.5 | 0.4 | 0.8 | 1.3 | 1.0 | 1.4 | 1.2 | 0.5 | 0.9 | 0.9 | 0.4 | 1.4 | | |

TABLE 7.—370 to 400 millimicrons—Continued.

B. AFTERNOON SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 24.1 | 19.1 | | 18.5 | 16.8 | | | 14.3 | | 19.4 | 11.6 | 6.0 | 1.4 | |
| AD ± | | 0.1 | | | | | | | | | 0.1 | | | | |
| March | 24.0 | 26.8 | 23.9 | 23.1 | 22.7 | 20.8 | 18.2 | | 13.7 | 15.5 | 23.5 | 12.2 | 7.8 | 3.5 | |
| AD ± | | 0.9 | 0.6 | 0.8 | 1.1 | | | | | | 0.8 | 0.5 | 0.0 | 0.4 | |
| April | 27.7 | 24.6 | 20.0 | 20.1 | 21.7 | 15.6 | 12.4 | 18.7 | | | 23.1 | 10.9 | 7.2 | 3.9 | 0.4 |
| AD ± | 0.9 | 1.0 | | 2.1 | 1.6 | | | 1.6 | | | 1.4 | 1.0 | 1.0 | 0.4 | |
| May | 25.7 | 26.2 | 23.1 | 19.6 | 21.2 | | 21.0 | | | | 24.0 | 13.2 | 7.1 | 3.4 | |
| AD ± | 1.5 | 1.7 | 3.4 | 1.4 | | | | | | | 1.8 | 0.0 | | | |
| June | 28.5 | 25.4 | 24.2 | 30.2 | 23.5 | | 24.7 | | | 19.5 | 25.5 | | 12.7 | | |
| AD ± | 0.2 | 0.6 | 2.7 | 2.5 | 0.2 | | 0.5 | | | | 1.0 | | | | |
| July | | | 17.7 | | | 11.5 | 25.2 | | | | 18.0 | | | | |
| AD ± | | | 3.8 | | | | | | | | 3.8 | | | | |
| August | 27.1 | 25.4 | 27.3 | 21.6 | 21.8 | 26.1 | 17.1 | 21.6 | | | 24.9 | 15.8 | 10.1 | 6.0 | |
| AD ± | 1.4 | 1.0 | 1.4 | 2.6 | | 0.4 | | 0.4 | | | 1.3 | 2.5 | 0.6 | 0.4 | |
| September | 32.1 | 28.9 | | | | 18.7 | | | 18.1 | | 26.5 | 14.8 | | | |
| AD ± | 0.7 | 2.0 | | | | | | | | | 1.3 | | | | |
| October | | 23.8 | 17.6 | | 6.4 | | 5.5 | | | | 14.1 | 7.6 | | | |
| AD ± | | 3.0 | 6.5 | | | | | | | | 4.4 | 2.8 | | | |
| November | | | | 14.9 | 18.4 | | | | | | 16.1 | | | | |
| AD ± | | | | 1.4 | | | | | | | 1.4 | | | | |
| December | | | | 21.6 | | | | | | | | | | | |
| AD ± | | | | 0.5 | | | | | | | | | | | |
| January | | | 22.6 | 21.9 | 26.6 | 20.4 | | 10.1 | | | 21.5 | 10.9 | | | |
| AD ± | | | 2.0 | 0.7 | | 0.2 | | | | | 0.9 | 2.2 | | | |
| M | 27.5 | 25.7 | 21.7 | 21.6 | 20.1 | 18.6 | 17.8 | 16.8 | 15.2 | 17.5 | 21.5 | 12.1 | 8.5 | 3.6 | 0.4 |
| AD ± | 0.8 | 0.4 | 0.9 | 0.9 | 1.2 | 1.3 | 2.0 | 2.6 | 1.2 | 1.4 | 1.0 | 0.6 | 0.8 | 0.5 | |

## C. TOTAL DAY.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 24.1 | 21.5 | | | 16.6 | | | | | 19.0 | 12.7 | 8.5 | | |
| AD ± | | 0.2 | 1.7 | | | 0.2 | | | | | 1.1 | 0.9 | 1.7 | | |
| March | 37.1 | 27.6 | 25.2 | 22.5 | 20.0 | 17.6 | 17.5 | | 16.2 | 14.6 | 23.1 | 12.4 | 8.4 | | |
| AD ± | 0.5 | 0.9 | 1.6 | 0.6 | 1.0 | 1.0 | 0.4 | | 1.0 | 0.2 | 0.7 | 0.2 | 0.4 | | |
| April | 28.4 | 25.3 | 23.8 | 22.0 | 21.5 | 19.4 | 16.1 | 19.1 | | | 23.6 | 12.3 | 10.6 | | |
| AD ± | 0.6 | 0.8 | 1.3 | 1.0 | 1.2 | 1.0 | 1.0 | 1.0 | | | 0.3 | 1.2 | 3.3 | | |
| May | 27.1 | 27.0 | 23.7 | 17.3 | 23.4 | | | | | | 24.6 | 13.5 | 11.3 | | |
| AD ± | 0.6 | 0.6 | 2.0 | 1.8 | 1.6 | | | | | | 0.8 | 0.4 | 3.0 | | |
| June | 27.7 | 26.7 | 24.8 | 27.3 | 24.4 | | | | | | 25.6 | | | | |
| AD ± | 0.6 | 0.7 | 1.1 | 1.1 | 0.7 | | | | | | 0.8 | | | | |
| July | | | 24.7 | | | 17.7 | 29.8 | | | | 23.9 | | | | |
| AD ± | | | 2.6 | | | 4.4 | 3.3 | | | | 2.4 | | | | |
| August | 27.9 | 25.2 | 25.9 | | | 23.0 | 16.1 | | | | 24.5 | 13.4 | | | |
| AD ± | 0.7 | 0.6 | 1.2 | | | 2.3 | 0.4 | | | | 1.0 | 1.4 | | | |
| September | 31.3 | 30.0 | | | | | | | | | 27.5 | 16.3 | | | |
| AD ± | 0.5 | 1.4 | | | | | | | | | 0.5 | 1.0 | | | |
| October | | 26.6 | 22.9 | | 14.0 | | | | | | 21.4 | | | | |
| AD ± | | 1.8 | 3.0 | | 5.4 | | | | | | 1.7 | | | | |
| November | | | | 15.6 | 22.6 | | | | | | | | | | |
| AD ± | | | | 1.2 | 3.0 | | | | | | | | | | |
| December | | | | 20.3 | | | | | | | | | | | |
| AD ± | | | | 1.3 | | | | | | | | | | | |
| January | | | 23.1 | 21.4 | 22.3 | 19.6 | | 14.2 | | | 20.6 | 11.7 | | | |
| AD ± | | | 1.1 | 0.9 | 1.4 | 1.2 | | 1.0 | | | 1.0 | 1.6 | | | |
| M | 30.1 | 26.6 | 24.0 | 20.9 | 21.3 | 19.0 | 19.9 | 16.6 | 16.2 | 14.6 | 23.4 | 13.2 | 10.2 | | |
| AD ± | 1.2 | 0.5 | 0.4 | 1.1 | 0.9 | 0.7 | 2.5 | 1.0 | 1.0 | 1.0 | 0.7 | 0.4 | 0.9 | | |

TABLE 8.—*400 to 460 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 71 | 65 | 57 | | 53 | | 48 | | | 58 | 49 | 46 | | |
| AD ± | | 0 | | | | | | 6 | | | 5 | 4 | 6 | | |
| March | 82 | 73 | 60 | 64 | 66 | 57 | 64 | 62 | 52 | 50 | 64 | 51 | 39 | | |
| AD ± | | 3 | 5 | 2 | 1 | 4 | | | 4 | | 4 | 2 | | | |
| April | 78 | 77 | 68 | 72 | 67 | 61 | 65 | 73 | 57 | 58 | 69 | 48 | | | |
| AD ± | 2 | 2 | 4 | 4 | 4 | 3 | 6 | | 2 | 11 | 3 | 5 | | | |
| May | 77 | 78 | 68 | 47 | 75 | 67 | | 52 | 65 | | 71 | 51 | 65 | | |
| AD ± | 2 | 2 | | | | 7 | | | 1 | | 2 | 1 | | | |
| June | 82 | 79 | 73 | 73 | 74 | 58 | | 55 | 55 | | 73 | 48 | | | |
| AD ± | 1 | 2 | 4 | 4 | | 6 | | 7 | 5 | | 3 | 3 | | | |
| July | | | 72 | | 70 | 68 | 70 | | | 58 | 73 | 51 | | | |
| AD ± | | | 1 | | 1 | | | | | | 1 | 3 | | | |
| August | 80 | 70 | 63 | | | 52 | 51 | | 69 | 36 | 68 | 41 | | | |
| AD ± | 3 | 3 | 7 | | | | 1 | | | | 3 | 3 | | | |
| September | 97 | 88 | 77 | 81 | | | 88 | | | | 88 | 58 | | | |
| AD ± | 1 | 2 | 4 | | | | 3 | | | | 2 | | | | |
| October | | 77 | 74 | 63 | 59 | | | | | | 73 | | | | |
| AD ± | | 4 | 6 | 3 | | | | | | | 4 | | | | |
| November | | | 67 | 49 | 73 | 40 | 70 | 41 | | 66 | 55 | 61 | | | |
| AD ± | | | | 3 | | | | 2 | | | 3 | 4 | | | |
| December | | | | 67 | 26 | 50 | 72 | 59 | | 66 | 59 | 55 | | | |
| AD ± | | | | 6 | 1 | 20 | 3 | 3 | | | 6 | 2 | | | |
| January | | | 73 | 65 | 57 | 60 | 59 | 63 | | 55 | 63 | 55 | | | |
| AD ± | | | 2 | 3 | 6 | 4 | | 7 | | 7 | 4 | 7 | | | |
| M | 83 | 77 | 69 | 64 | 63 | 57 | 67 | 57 | 60 | 56 | 63 | 61 | 50 | | |
| AD ± | 2 | 1 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 6 | | |

B. AFTERNOON SUN.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 77 | 60 | | 75 | 57 | | | 52 | | 66 | 41 | 32 | 11 | |
| AD ± | | 6 | | | | | | | | | 6 | | | | |
| March | 68 | 79 | 76 | 73 | 70 | 69 | 72 | | 62 | 52 | 74 | 49 | 43 | 23 | |
| AD ± | | 2 | 4 | 2 | 7 | | | | | | 3 | 2 | 4 | 2 | |
| April | 80 | 72 | 57 | 65 | 60 | 61 | 40 | 56 | | | 69 | 52 | 31 | 25 | 5 |
| AD ± | 3 | 2 | | 3 | 1 | | | 4 | | | 3 | 6 | 4 | 3 | |
| May | 71 | 73 | 63 | 67 | 66 | | 5; | | | | 69 | 43 | 38 | 24 | |
| AD ± | 4 | 5 | 7 | 4 | | | | | | | 4 | 1 | | | |
| June | 78 | 74 | 66 | 76 | 77 | | 72 | | | 54 | 84 | | 41 | | |
| AD ± | 5 | 3 | 7 | 1 | 4 | | 5 | | | | 4 | | | | |
| July | | | 46 | | | 34 | 73 | | | | 50 | | | | |
| AD ± | | | 6 | | | | | | | | 6 | | | | |
| August | 76 | 81 | 75 | 67 | 64 | 79 | 46 | 74 | | | 65 | 57 | 44 | 32 | |
| AD ± | 5 | 2 | 5 | 6 | | 1 | | 1 | | | 4 | 7 | 6 | 1 | |
| September | 88 | 92 | | | | 59 | | | 66 | | 81 | 58 | | | |
| AD ± | 6 | 3 | | | | | | | | | 4 | | | | |
| October | | 72 | 30 | | 20 | | 22 | | | | 38 | 31 | | | |
| AD ± | | 13 | 4 | | | | | | | | 8 | 9 | | | |
| November | | | | 58 | 57 | | | | | | 58 | | | | |
| AD ± | | | | 2 | | | | | | | 2 | | | | |
| December | | | | 71 | | | | | | | | | | | |
| AD ± | | | | 3 | | | | | | | | | | | |
| January | | | 66 | 75 | 67 | 70 | | 59 | | | 71 | 51 | | | |
| AD ± | | | 6 | 2 | | 1 | | | | | 27 | 4 | | | |
| M | 77 | 78 | 60 | 69 | 62 | 61 | 55 | 63 | 60 | 53 | 66 | 48 | 38 | 23 | 5 |
| AD ± | 2 | 2 | 3 | 1 | 4 | 4 | 6 | 4 | 3 | 1 | 3 | 2 | 2 | 2 | |

TABLE 8.—*400 to 460 millimicrons*—Continued.

C. TOTAL DAY.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 74 | 68 | | | 55 | | | | | 61 | 48 | 41 | | |
| AD ± | | 3 | 2 | | | 1 | | | | | 4 | 4 | 8 | | |
| March | 75 | 76 | 68 | 69 | 66 | 60 | 68 | | 55 | 51 | 69 | 51 | 42 | | |
| AD ± | 5 | 2 | 4 | 2 | 2 | 3 | 3 | | 4 | 1 | 1 | 1 | 3 | | |
| April | 79 | 75 | 67 | 69 | 65 | 61 | 60 | 62 | | | 68 | 50 | | | |
| AD ± | 2 | 1 | 3 | 2 | 2 | 3 | 6 | 5 | | | 1 | 4 | | | |
| May | 79 | 76 | 65 | 61 | 70 | | | | | | 71 | 48 | 52 | | |
| AD ± | 2 | 2 | 4 | 8 | 3 | | | | | | 3 | 2 | 10 | | |
| June | 81 | 77 | 69 | 74 | 76 | | | | | | 64 | | | | |
| AD ± | 1 | 2 | 3 | 2 | 3 | | | | | | 2 | | | | |
| July | | | 62 | | | 51 | 72 | | | | 63 | | | | |
| AD ± | | | 5 | | | 12 | 1 | | | | 12 | | | | |
| August | 77 | 77 | 71 | | | 70 | 49 | | | | 71 | 45 | | | |
| AD ± | 3 | 3 | 4 | | | 7 | 1 | | | | 3 | 3 | | | |
| September | 94 | 89 | | | | | | | | | 85 | 58 | | | |
| AD ± | 2 | 2 | | | | | | | | | 3 | | | | |
| October | | 76 | 56 | | 40 | | | | | | 60 | | | | |
| AD ± | | 6 | 5 | | 14 | | | | | | 5 | | | | |
| November | | | | 54 | 65 | | | | | | 56 | | | | |
| AD ± | | | | 3 | 5 | | | | | | 2 | | | | |
| December | | | | 68 | | | | | | | | | | | |
| AD ± | | | | 6 | | | | | | | | | | | |
| January | | | 71 | 71 | | 63 | | 61 | | | 66 | 47 | | | |
| AD ± | | | 3 | 2 | | 3 | | 7 | | | 12 | 6 | | | |
| M | 81 | 78 | 66 | 67 | 64 | 60 | 62 | 61 | 55 | 51 | 67 | 50 | 45 | | |
| AD ± | 2 | 1 | 1 | 2 | 3 | 2 | 4 | 6 | 4 | 1 | 2 | 1 | 3 | | |

TABLE 9.—*290 to 1,400 millimicrons.*

[Microwatts per square millimeter.]

A. MORNING SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 815 | 803 | 722 | | 679 | | 664 | | | 728 | 678 | 664 | | |
| AD ± | | 6 | | | | | | 61 | | | 40 | 33 | 60 | | |
| March | 890 | 849 | 799 | 764 | 766 | 688 | 770 | 730 | 704 | 676 | 778 | 680 | 620 | | |
| AD ± | | 14 | 46 | 19 | 9 | 14 | | | 52 | | 21 | 16 | | | |
| April | 876 | 857 | 804 | 813 | 791 | 756 | 790 | 824 | 736 | 726 | 807 | 689 | | | |
| AD ± | 11 | 15 | 34 | 32 | 31 | 30 | 17 | | 18 | 89 | 16 | 50 | | | |
| May | 811 | 818 | 760 | 661 | 855 | 727 | | 682 | 754 | | 784 | 629 | 690 | | |
| AD ± | 19 | 20 | | 132 | | 31 | | | 4 | | 32 | 26 | | | |
| June | 854 | 843 | 805 | 825 | 832 | 697 | | 746 | 700 | | 775 | 665 | | | |
| AD ± | 7 | 7 | 9 | 10 | | 68 | | 62 | 54 | | 16 | 14 | | | |
| July | | | 858 | | 818 | 827 | 834 | | 727 | 727 | 814 | 642 | | | |
| AD ± | | | 18 | | 16 | | | | | | 17 | 16 | | | |
| August | 848 | 766 | 746 | | | 655 | 602 | | 797 | 443 | 750 | 573 | | | |
| AD ± | 20 | 20 | 52 | | | | 25 | | | | 24 | 29 | | | |
| September | 919 | 913 | 812 | 820 | | | 804 | | | | 870 | 729 | | | |
| AD ± | 7 | 3 | 40 | | | | 17 | | | | 15 | | | | |
| October | | 839 | 802 | 718 | 736 | | | | | | 802 | | | | |
| AD ± | | 46 | 49 | 23 | | | | | | | 44 | | | | |
| November | | | 770 | 627 | 848 | 662 | 860 | 603 | | 656 | 704 | 556 | | | |
| AD ± | | | | 66 | | | 4 | 23 | | 36 | 38 | 76 | | | |
| December | | | | 738 | 275 | 512 | 777 | 729 | | 736 | 665 | 658 | | | |
| AD ± | | | | 40 | 7 | 194 | 14 | 2 | | | 43 | 13 | | | |
| January | | | 829 | 786 | 756 | 734 | 749 | 735 | | 689 | 764 | 658 | | | |
| AD ± | | | 22 | 18 | 22 | 36 | | 29 | | 67 | 28 | 23 | | | |
| M | 867 | 837 | 797 | 747 | 708 | 694 | 774 | 714 | 736 | 665 | 778 | 652 | 658 | | |
| AD ± | 12 | 8 | 6 | 17 | 43 | 17 | 18 | 17 | 10 | 30 | 11 | 11 | | | |

TABLE 9.—*290 to 1,400 millimicrons*—Continued.

B. AFTERNOON SUN.

| Month. | Air mass. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | <2.0 | 2.0 | 3.0 | 4.0 | 5.0 |
| February | | 802 | 730 | | 735 | 700 | | | 665 | | 739 | 612 | 487 | 270 | |
| AD ± | | 16 | | | | | | | | | 16 | | | | |
| March | 770 | 866 | 860 | 831 | 821 | 820 | 816 | | 714 | 717 | 835 | 650 | 562 | 447 | |
| AD ± | | 8 | 8 | 19 | 33 | | | | | | 10 | 16 | 4 | 17 | |
| April | 869 | 835 | 756 | 781 | 774 | 700 | 637 | 746 | | | 773 | 641 | 543 | 468 | 240 |
| AD ± | 13 | 15 | | 20 | 16 | | | 24 | | | 16 | 27 | 28 | 16 | |
| May | 775 | 807 | 716 | 720 | 755 | | 752 | | | | 764 | 657 | 514 | 413 | |
| AD ± | 41 | 29 | 86 | 70 | | | | | | | 48 | 2 | | | |
| June | 842 | 784 | 734 | 849 | 839 | | 860 | | | 745 | 806 | | 616 | | |
| AD ± | 30 | 26 | 75 | 5 | 11 | | 24 | | | | 32 | | | | |
| July | | | 481 | | | 382 | 815 | | | | 540 | | | | |
| AD ± | | | 100 | | | | | | | | 100 | | | | |
| August | 794 | 804 | 811 | 733 | 753 | 895 | 641 | 850 | | | 798 | 694 | 593 | 526 | |
| AD ± | 36 | 29 | 51 | 70 | | 14 | | 19 | | | 38 | 79 | 100 | 27 | |
| September | 913 | 864 | | | | 702 | | | 804 | | 843 | 745 | | | |
| AD ± | 9 | 36 | | | | | | | | | 22 | | | | |
| October | | 744 | 374 | | 212 | | 234 | | | | 423 | 398 | | | |
| AD ± | | 123 | 91 | | | | | | | | 102 | 130 | | | |
| November | | | | 803 | 658 | 568 | | | | | 708 | | | | |
| AD ± | | | | 41 | | | | | | | 47 | | | | |
| December | | | | 773 | | | | | | | | | | | |
| AD ± | | | | 2 | | | | | | | | | | | |
| January | | | 827 | 817 | 260 | 794 | | 775 | | | 818 | 710 | | | |
| AD ± | | | 30 | 15 | | 18 | | | | | 13 | 29 | | | |
| M | 827 | 814 | 676 | 790 | 645 | 697 | 679 | 757 | 712 | 731 | 732 | 638 | 553 | 425 | 240 |
| AD ± | 20 | 11 | 44 | 13 | 61 | 39 | 57 | 24 | 27 | 10 | 29 | 24 | 15 | 30 | |

C. TOTAL DAY.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| February | | 804 | 767 | | | 690 | | | | | 733 | 661 | 598 | | |
| AD ± | | 9 | 26 | | | 7 | | | | | 18 | 25 | 76 | | |
| March | 830 | 859 | 830 | 797 | 788 | 721 | 793 | | 713 | 697 | 805 | 670 | 581 | | |
| AD ± | 43 | 8 | 22 | 17 | 15 | 25 | 16 | | 33 | 15 | 9 | 11 | 15 | | |
| April | 873 | 849 | 800 | 799 | 798 | 763 | 752 | 772 | | | 816 | 662 | | | |
| AD ± | 9 | 11 | 26 | 20 | 17 | 30 | 25 | 23 | | | 6 | 28 | | | |
| May | 800 | 852 | 730 | 691 | 805 | | | | | | 723 | 640 | 602 | | |
| AD ± | 16 | 5 | 52 | 69 | 29 | | | | | | 20 | 12 | 63 | | |
| June | 852 | 816 | 769 | 834 | 837 | | | | | | 808 | | | | |
| AD ± | 9 | 14 | 30 | 8 | 7 | | | | | | 15 | | | | |
| July | | | 707 | | | 605 | 825 | | | | 729 | | | | |
| AD ± | | | 83 | | | 160 | 7 | | | | 60 | | | | |
| August | 825 | 790 | 789 | | | 815 | 630 | | | | 804 | 621 | | | |
| AD ± | 19 | 21 | 41 | | | 43 | | | | | 26 | 29 | | | |
| September | 917 | 897 | | | | | | | | | 863 | 737 | | | |
| AD ± | 7 | 11 | | | | | | | | | 17 | 6 | | | |
| October | | 815 | 630 | | 474 | | | | | | 660 | | | | |
| AD ± | | 59 | 64 | | 187 | | | | | | 62 | | | | |
| November | | | | 710 | 753 | 615 | | | | | 706 | | | | |
| AD ± | | | | 58 | 68 | 33 | | | | | 42 | | | | |
| December | | | | 745 | | | | | | | | | | | |
| AD ± | | | | 36 | | | | | | | | | | | |
| January | | | 828 | 806 | 860 | 753 | | 755 | | | 787 | 678 | | | |
| AD ± | | | 25 | 16 | | 31 | | | | | 22 | 25 | | | |
| M | 860 | 835 | 761 | 767 | 759 | 666 | 728 | 778 | 713 | 697 | 767 | 667 | 594 | | |
| AD ± | 14 | 11 | 20 | 18 | 31 | 28 | 71 | | 33 | 15 | 15 | 9 | 5 | | |

## DISCUSSION

On examining the tables of results the most striking feature is the absence of a marked peak of values such as has been found for June and adjacent months by other observers in more northerly latitudes. The monthly curve of values is quite flat. Several factors contribute to this uniformity of radiation throughout the year. Due to the low latitude, the air mass tends to remain at low values for a greater portion of the day, even during the "winter" months. Further, in contrast to other places which have been studied, the months of November to February in Manila usually give the best weather of the year. Even in 1932, when the weather was unusually cloudy, those days not markedly cloudy were clear and sparkling. On the other hand, the "summer" months which show maximum values in the United States fall in the rainy season in Manila when, even if the sun appears clear, there is apt to be a visible haziness even though this be sufficiently uniform to permit observations.

The chief value of a report of this nature must be for purposes of comparison with similar work in other places. Unfortunately, such work giving data susceptible of comparison with the present values is very scarce up to now and even of this not much is available here in the Philippines. The figures reported on work done by photochemical methods are not reducible to energy units. Indeed, for the most part, comparison of the reports of different workers with even similar photochemical methods appears difficult if not impossible. Certainly it requires more exactly defined working conditions and data on instruments used than have been given in any such work so far seen. And to attempt to compare work reported in milligrams of oxalic acid decomposed with work based on time of fading of dyes is beyond the writer.

If the radiometric program adopted at the II$^{e}$ Congress International de La Lumiere as reported by Coblentz(3) can be carried out, comparable values may, in time, become available from widely distant regions. This program is based on the use of thermopile methods and contemplates three standard glasses being adopted for filters by all workers.

For the spectral regions λ 310 to 370, λ 370 to 400 and λ 400 to 460 millimicrons, the only figures available to the writer for comparison are those obtained by him in Baguio, Mountain Province, P. I., as reported previously.(4) The values now reported

are placed on record in the hope that the writer and other workers may be able to obtain values for comparison from other localities in the future.

For the band λ 290 to 310 millimicrons, a few figures are available for comparison. This band comprises the so-called Vital U. V. in which so much interest has been shown of late. Mayerson and Laurens(5) have recently published results obtained in New Orleans, by a thermopile-filter method. Coblentz, Stair, and Hogue(6, 7) have published results obtained in Washington, likewise by a thermopile-filter method. While the methods used by these workers and by the writer are similar, the filters used to determine the spectral band were of different glass in each case. Hence the exact limits of the bands reported differ. The limiting wave length between the first two spectral bands used by the writer is 310 millimicrons, while the other workers quoted have taken 313 millimicrons as the limit. Window glass filter No. 30 here used to determine the upper limit of the first band showed perceptible transmission of the strong mercury line λ 313. Hence its zero cut-off was taken at λ 310. However, the amount of energy in sunlight lying between these two limits is small. Furthermore, any difference would be added to the band λ 290 to 313 which is of chief interest for comparison with the results of others. Hence in these comparisons, since the Manila figures are usually the larger, any discrepancies would only intensify the dissimilarity of the sunlight in Manila and elsewhere. However, these differences are believed to be of small magnitude. The values obtained by these workers in New Orleans and Washington are compared with the present Manila figures in Tables 10 and 11.

Values have been reduced to microwatts per square millimeter as used in the present report. Air masses for New Orleans have been calculated for the 15th day of each month.

Table 10 presents the figures for the three cities on a basis of 10 a. m. The approximate air masses at 10 a. m. for the three places are shown. In the winter months an explanation of the greater solar energy in Manila is readily found in the much lower air mass at 10 a. m. than in the northern cities. For the summer months, in which the air masses are nearly the same at 10 a. m., the solar energy is nearly the same in New Orleans and Manila. On the other hand, the Washington values are noticeably greater.

TABLE 10.—*Energy at 10 a. m. in band λ 290 to 310 millimicrons.*

| Month. | Manila. | | New Orleans. (5) | | Washington. (6) (7) | |
|---|---|---|---|---|---|---|
| | Air mass. | Microwatts per mm². | Air mass. | Microwatts per mm². | Air mass. | Microwatts per mm². |
| January | 1.5 | 0.41 | 2.0 | 0.17 | | |
| February | 1.3 | 0.23 | 1.7 | 0.15 | 1.75 | 0.33 |
| March | 1.2 | 0.54 | 1.4 | 0.28 | | |
| April | 1.1 | 0.47 | 1.2 | 0.36 | | |
| May | 1.1 | 0.50 | 1.1 | 0.36 | | |
| June | 1.1 | 0.51 | 1.1 | 0.50 | 1.2 | 0.60 to 0.80 |
| July | 1.2 | 0.45 | 1.2 | 0.45 | | |
| August | 1.2 | 0.65 | 1.2 | 0.46 | | |
| September | 1.2 | 0.44 | 1.3 | 0.32 | | |
| October | 1.2 | 0.52 | 1.4 | 0.26 | | |
| November | 1.3 | 0.51 | 1.7 | 0.20 | [a] 2.4 | 0.08 to 0.22 |
| December | 1.6 | 0.47 | 2.1 | 0.13 | | |

[a] Mean.

TABLE 11.—*Energy for same air mass in band λ 290 to 310 millimicrons.*

| Month. | Air mass. | New Orleans. (5) | | Manila. | Air mass. | Washington. (6) (7) | Manila. |
|---|---|---|---|---|---|---|---|
| | | 1930 | 1931 | 1932 | | 1930 | 1932 |
| | | *Microwatts per mm².* | | | | *Microwatts per mm².* | |
| January | 2.0 | 0.18 | 0.16 | 0.26 | | | |
| February | 1.7 | 0.15 | 0.14 | 0.22 | | | |
| March | 1.4 | 0.27 | 0.28 | 0.32 | | | |
| April | 1.2 | 0.37 | 0.34 | 0.55 | | | |
| May | 1.1 | 0.39 | 0.32 | 0.50 | | | |
| June | 1.1 | 0.59 | 0.40 | 0.51 | 1.1 | 0.90 | 0.51 |
| | | | | | 1.2 | 0.60 to 0.80 | 0.43 |
| July | 1.2 | | 0.45 | 0.45 | 1.2 | 0.57 | 0.45 |
| August | 1.2 | 0.40 | 0.52 | 0.65 | | | |
| September | 1.3 | 0.32 | | 0.34 | | | |
| October | 1.4 | 0.26 | 0.26 | 0.43 | | | |
| November | 1.7 | 0.20 | 0.19 | 0.26 | | | |
| December | 2.1 | 0.13 | | 0.20 | | | |

In Table 11 the Manila values are taken for that same air mass for the month as obtained in New Orleans at 10 a. m. Most of the Manila figures are larger than those for New Orleans. The Washington figures are mostly decidedly higher than those for Manila. Whether this is due to the small number of the Washington observations or to a fundamental difference in the filters and their reduction factors used cannot be said at present. Since single values have been obtained in Manila larger than the Washington values, the writer is inclined to attribute part

at least of the difference to the small number of Washington observations available.

### MORNING-AFTERNOON RATIO OF ERYTHEMIC LIGHT

There is a very common impression in Manila that the morning sunlight will produce a marked sunburn with short exposure, while the afternoon sunlight rarely burns. Golfers, tennis players and swimmers, who are customarily exposed to the afternoon sun with a resultant tan of moderate degree, frequently report moderate to painful degrees of erythema from exposure to morning sunlight. To examine this question the ratios of the microwatt values for the morning and afternoon sun have to be computed for the band $\lambda$ 290 to 310 millimicrons. This band contains the sharply defined maximum of the erythemic energy at $\lambda$ 299 millimicrons.(8) For comparison, the ratios of the yearly means for each air mass were computed in three ways, as follows:

(*a*) The ratio of the a. m. to p. m. means.
(*b*) The ratio of these same means but with the AD of the a. m. value *added* and the AD of the p. m. value *subtracted.* This gives the maximum probable ratio.
(*c*) The same ratio but with the AD of the a. m. value *subtracted* and the AD of the p. m. value *added.* This gives the minimum probable value.

The results are given in Table 12.

TABLE 12.—*Ratio of morning ultraviolet to afternoon ultraviolet.*

| Air mass. | Wave lengths 290-310 millimicrons. | | |
|---|---|---|---|
| | A. M./P. M. | A. M.+AD/P. M.—AD. | A. M.—AD/P. M.+AD. |
| 1.0 | 1.06 | 1.15 | 0.97 |
| 1.1 | 0.98 | 1.09 | 0.89 |
| 1.2 | 1.11 | 1.23 | 1.00 |
| 1.3 | 0.88 | 1.02 | 0.75 |
| 1.4 | 0.93 | 1.08 | 0.80 |
| 1.5 | 1.06 | 1.31 | 0.87 |
| 1.6 | 1.33 | 1.65 | 1.09 |
| 1.7 | 0.86 | 0.97 | 0.83 |
| 1.8 | 1.73 | 2.13 | 1.41 |
| 1.9 | 0.79 | 1.00 | 0.62 |
| Less than 2.0 | 0.96 | 1.07 | 0.86 |
| 2.0 | 0.95 | 1.12 | 0.81 |
| 3.0 | 1.00 | 1.28 | 0.80 |
| Mean | 1.04±.04 | 1.24±.06 | 0.98±.05 |
| Mean without air mass 1.8 | 0.99±.03 | 1.16±.04 | 0.86±.03 |

While this table does show some high ratios, these occur irregularly and in the midst of low ratios. The very high ratios for air mass 1.8 are considered to be entirely accidental, being preceded and followed by very low ratios, and to be due to the fact that the p. m. values for this air mass are based on figures for three months only, each of these monthly values comprising only a single instrumental run each. However, even if these high ratios be retained, the resulting mean ratios are too near unity to be regarded as showing sufficient excess ultraviolet in the morning sunlight to explain the popular belief, the maximum mean ratio obtained being 1.30 (1.24+0.06). The most probable explanation of the greater frequency of sunburn in the morning appears to be the hours of exercise customary in Manila. Morning tennis, golf or swimming usually occur between 9 a. m. and noon, when the air mass is less than 1.5. In contrast to this, the afternoon exercise is usually taken after 3 p. m., by which time the air mass is greater than 1.5. Coblentz and his associates (8) give 500,000 ergs per square centimeter as the minimum erythemic dose for monochromatic radiation of $\lambda$ 297 millimicrons. From tables 5–A and 5–B the mean radiation of $\lambda$ 290 to 310 millimicrons for a. m. air mass less than 1.5 is 0.52 microwatts per square millimeter, and for p. m. air mass 1.5 to 2.0, 24 microwatts per square millimeter.

These give respective exposure times for minimum erythema reactions of $\frac{5 \times 10^{3} \text{ ergs}}{\text{mm}^{2}} \times \frac{10^{-7} \text{ joule}}{\text{erg}} \times \frac{1 \text{ watt second}}{\text{joule}} \times \frac{1 \text{ mm}^{2}}{0.52 \times 10^{-6} \text{ watts}} = 1000 \text{ sec.} = 17$ minutes for the customary morning exercise time and $\frac{5 \times 10^{3} \text{ ergs}}{\text{mm}^{2}} \times \frac{10^{-7} \text{ joule}}{\text{erg}} \times \frac{1 \text{ watt second}}{\text{joule}} \times \frac{1 \text{ mm}^{2}}{0.24 \times 10^{-6} \text{ watts}} = 35$ minutes for the afternoon.

The ratio of $\frac{35 \text{ p. m. minutes}}{\text{a. m. minutes}}$ or, approximately 2, seems to make the difference in air mass for the respective exercise times a more adequate explanation of the popular belief than any essential difference in the morning and afternoon light for the same air mass.

### ANTIRACHITIC EFFICIENCY OF MANILA SUNLIGHT

Mayerson and Laurens, (5) in New Orleans, found the maximum daily solar radiation of wave length less than 313 necessary

to prevent rickets in rats to be 0.002 gram calories per square centimeter. This is equal to 140 microwatt minutes per square centimeter or 1.4 microwatt minutes per square millimeter.

The minimum value for this protective spectral band found in Manila was 0.12 microwatts per square millimeter (October, air mass 1.6, 3.30 p. m.). If we assume that the values for rats may be applied to humans, particularly to brown-skinned Filipinos, it appears that about 15 minutes' exposure of the entire body surface to sunlight even this late in the day should prevent rickets, while at noon, when the average value of 0.70 microwatts per square millimeter was found, a two-minute exposure should suffice for protection. When the scanty clothing of the children in Manila and their constant exposure to sunlight in all months of the year is remembered, the above figures seem adequate to explain the rarity of rickets in Manila.

## PHOTOGRAPHIC EFFICIENCY OF MANILA SUNLIGHT

It is usually surprising to newcomers to Manila to find that photographic exposures must be from 1.5 to 2 times the normal exposure in more northerly places. From conversations and other reports (9) it appears this holds true for elsewhere in the Tropics. While all four of the spectral bands studied have intense photographic action, it is probable that only the one limited by λ 400 to 460 millimicrons is transmitted by photographic lenses to a sufficient degree to be of importance photographically.

No figures for this spectral band from outside the Tropics are available to the writer for comparison with the Manila figures. However, as previously reported, (4) the writer has obtained data on the sunlight at Baguio, Mountain Province, P. I. This is in the mountains of northern Luzon, some 160 miles north of Manila, 16° 24′ north latitude and 4,800 feet above sea level. This, of course, is very close to Manila as far as tropical location, but the altitude gives it a climate much more temperate. Adequate photographic exposures in Baguio are practically the same as in the States, and negatives taken there with the same exposures as are needed in Manila are overexposed.

Table 14 gives the ratios Baguio to Manila of the energy in the spectral band λ 400 to 460 millimicrons arranged by air mass. Two ratios are given, namely:

(*a*) The ratio of the Baguio light in January, 1932, to the Manila light in December, 1931; (4)

(*b*) The ratio of the Baguio light in January, 1932, to the yearly means of Manila light, February, 1932, to January, 1933. The comparison is made under two heads; namely, percentages and microwatts per square millimeter and for morning and afternoon separately.

TABLE 14.—*Ratio of solar energy of λ 400 to 460 millimicrons in Baguio and Manila, P. I.*

PERCENTAGES OF TOTAL SOLAR ENERGY.

| Period. | Air mass. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.0 | 3.0 | 4.0 | Mean. |
| | *Morning sun.* | | | | | | | | | | | |
| Jan. 1932 to Dec. 1931 | 1.0 | 0.9 | 1.0 | 0.8 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 1.2 | ----- | 1.0 |
| Jan. 1932 to year 1932 | 1.09 | 1.01 | 1.02 | 1.04 | 1.02 | 1.09 | 1.01 | 1.16 | ------ | ----- | ----- | 1.06 |
| | *Afternoon sun.* | | | | | | | | | | | |
| Jan. 1932 to Dec. 1931 | 0.8 | 1.2 | 0.9 | 0.8 | ------ | 1.0 | ------ | ------ | 0.9 | 1.0 | 0.9 | 0.9 |
| Jan. 1932 to year 1932 | 1.03 | 0.97 | 0.97 | 1.00 | 1.02 | 1.09 | 1.15 | ------ | ------ | ----- | ----- | 1.03 |

MICROWATTS PER SQUARE MILLIMETER.

| Period. | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 | 2.0 | 3.0 | 4.0 | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Morning sun.* | | | | | | | | | | | |
| Jan. 1932 to Dec. 1931 | 1.2 | 1.1 | 1.2 | 1.0 | 1.3 | 1.2 | 1.2 | 1.8 | 1.2 | 2.3 | ----- | 1.3 |
| Jan. 1932 to year 1932 | 1.4 | 1.4 | 1.4 | 1.5 | 1.3 | 1.5 | 1.3 | 1.6 | ------ | ----- | ----- | 1.4 |
| | *Afternoon sun.* | | | | | | | | | | | |
| Jan. 1932 to Dec. 1931 | 1.0 | 1.1 | 1.2 | 1.1 | ------ | 1.1 | ------ | ------ | 1.3 | 1.4 | 1.1 | 1.2 |
| Jan. 1932 to year 1932 | 1.6 | 1.2 | 1.4 | 1.4 | 1.5 | 1.3 | 1.3 | ------ | ------ | ----- | ----- | 1.4 |

The percentages of energy in this band do not differ greatly in the two places. The greatest difference found gave the greatest percentage of the light to Manila. However, when the absolute amounts of energy present were compared there was about one-third more of this photographically active light present in Baguio than in Manila. Hence it would appear from this meager data that the necessary increase in exposure in Manila is due not so much to a qualitative photographic difference in the light

but to a lower total intensity. This is strikingly at variance with the visual effect of tropical sunlight, a light so intense visually as to hurt the eyes, yet weak photographically. The quantitative difference in the light of about one-third falls somewhat short of the necessary increase of photographic exposure. It may be that the mere increase in altitude of Baguio does not have the same effect on the light as does change to a more northern latitude even if the photographic exposure does become normal.

## CONCLUSIONS

Due to the lack of more extensive data for comparison, only the following conclusions can be drawn from the material here presented.

1. The solar ultraviolet energy of $\lambda$ 290 to 310 millimicrons is greater at 10 a. m. in Manila than in New Orleans, except during the months of June and July. This is due to the lesser air mass through which the light is filtered in Manila at the same time of day. The excess energy found in Manila is roughly proportionate to this difference in air mass.

2. For equal air mass the solar ultraviolet energy in Manila is slightly greater than in New Orleans. This excess is so slight that it is probably an accidental variation due to the smallness of sample in both cases. The same explanation is true of values in Washington, D. C., compared with Manila.

3. The popular belief that the morning sun in Manila will cause sunburn more readily than the afternoon sun is attributed to the fact that the customary hours of exposure in the afternoon are to sunlight filtered through a greater air mass and not to any real difference of the light in morning and afternoon at times equally distant from midday.

4. The antirachitic efficiency of Manila sun is such that fifteen minutes' daily exposure of the entire skin surface to sunlight in October at 3.30 p. m. or two minutes' similar exposure at noon throughout the year should protect against rickets.

5. The longer photographic exposures found necessary in Manila are partially explained by a deficiency in solar energy of $\lambda$ 400 to 460 millimicrons as compared with solar energy of the same wave lengths found in Baguio, Philippine Islands, at 4,800 feet above sea level. This deficiency, as far only as these two places are concerned, is due more to a quantitative deficiency of total sunlight received than to any qualitative difference in this spectral region.

ACKNOWLEDGMENT

To the kindly personal encouragement and official support in this work of the Department Surgeons, Philippine Department, United States Army, Colonel Henry H. Rutherford, Medical Corps, and Colonel Kent Nelson, Medical Corps, and of the Presidents of the United States Army Medical Department Research Board, Major Rufus L. Holt, Medical Corps, and Major Seymour C. Schwartz, Medical Corps, the writer is greatly indebted. He is very grateful to the Reverend Miguel Selga, S. J., director of the Philippine Weather Bureau, for placing all the facilities of the Weather Bureau at his disposal, especially for giving him a suitable place for the instrumental observations and for a great deal of valuable help and advice on matters of theory. Finally, the writer would acknowledge a large debt of gratitude to Pvt. First Class Gervacio R. Sales, Medical Department, Philippine Scouts. To his patient and painstaking handling of the thermopile in making the observations, exposed for long hours to the full heat of the sun, this work owes all it may have accomplished. In truth, he has borne the heat and burden of the day.

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ABSTRACT

Solar energy values for three spectral regions in the ultraviolet and one region in the violet are reported for Manila, Philippine Islands, for a twelve-month period.

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# THE VITAMIN CONTENT OF PHILIPPINE FOODS, II

## VITAMIN C IN VARIOUS FRUITS AND VEGETABLES

By A. J. HERMANO and GAVINO SEPULVEDA, Jr.
*Of the Bureau of Science, Manila*

ONE PLATE AND SIXTEEN TEXT FIGURES

Investigations of vitamins have shown that the lack of vitamin C in the diet leads to the development of scurvy. Aside from its antiscorbutic property vitamin C plays an important rôle in the process of normal metabolism. Scurvy affects the nutritional condition and the normal function of some important tissues of the body. The object of the work here reported was to determine the vitamin C content of the commonest Philippine fruits and vegetables. Filipinos depend mostly on native fruits and vegetables for their vitamin C supply.

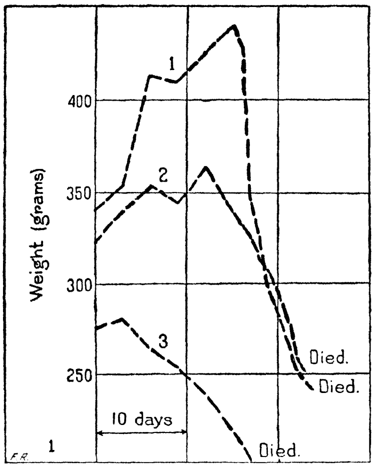
Embrey(1) tested a few samples of Chinese and Philippine fruits and vegetables for their vitamin C content. Some of them gave very satisfactory results.

Perry and Silva(2) experimented on three varieties of mango grown in India. According to their results, "Alphonso" variety is one of the most potent natural sources of vitamin C; "Cawasji Patel" is slightly less active, and the "Shendrya" variety is rather poor in vitamin C.

### MATERIALS AND EXPERIMENTAL PROCEDURE

The materials used in this investigation were purchased in the public markets of Manila. They consisted of fifteen kinds of fruits and leafy vegetables as follows:

Fruits:
- Mango (carabao and pico varieties); *Mangifera indica* Linn.
- Lansones; *Lansium domesticum* Correa.



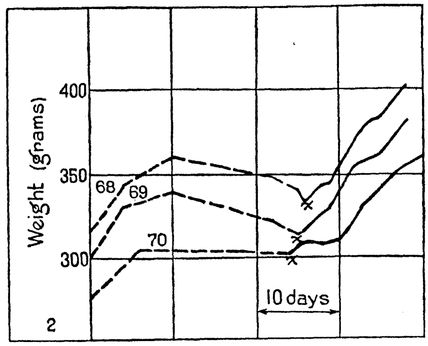




FIG. 1. Guinea pigs 1, 2, and 3 were fed with the basal diet. They all died after seventeen to twenty-four days of feeding.

FIG. 2. Guinea pigs 68, 69, and 70 were fed with the basal diet until scurvy was produced. From the point X each animal received daily 10 cubic centimeters of atis in addition to the basal diet. All were cured of scurvy. Atis is a good source of vitamin C.

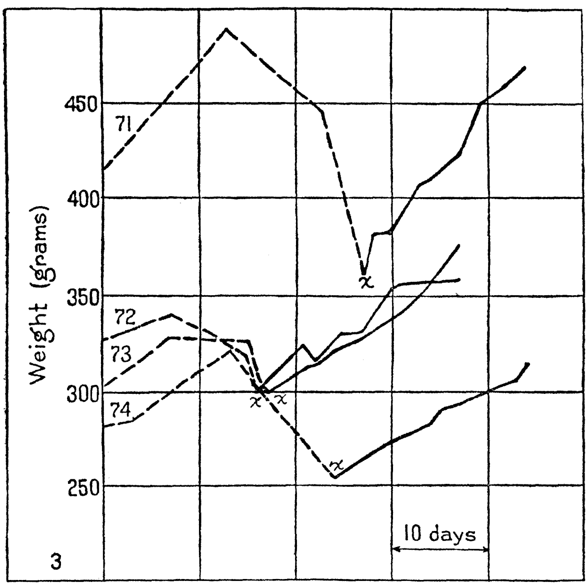
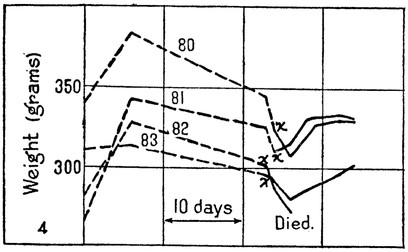



FIG. 3. Guinea pigs 71, 72, 73, and 74 were fed with the basal diet until scurvy was produced. From the point X each animal received daily 8 cubic centimeters of guayabano in addition to the basal diet. All were cured of scurvy. Guayabano is an excellent source of vitamin C.



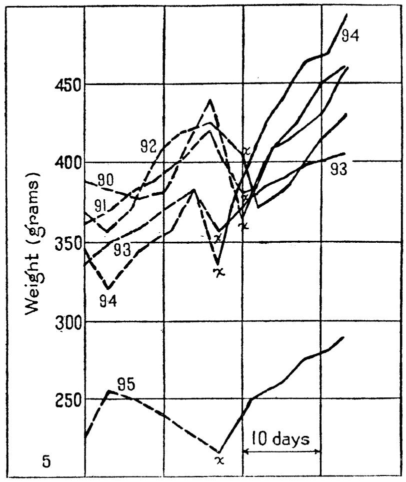




FIG. 4. Guinea pigs 80, 81, 82, and 83 were fed with the basal diet until scurvy was produced. From the point X each animal received daily 10 cubic centimeters of lansones in addition to the basal diet. Three guinea pigs recovered very slowly and one died. Lansones contain vitamin C.

FIG. 5. Guinea pigs 90, 91, 92, 93, 94, and 95 were fed with the basal diet until scurvy was produced. From the point X guinea pigs 90, 91, 92, and 95 each received daily 6 cubic centimeters of mango, carabao variety, in addition to the basal diet. No. 93 received daily from the point X, 7 cubic centimeters of mango and No. 94 received 8 cubic centimeters. All were cured of scurvy. Carabao variety is an excellent source of vitamin C.

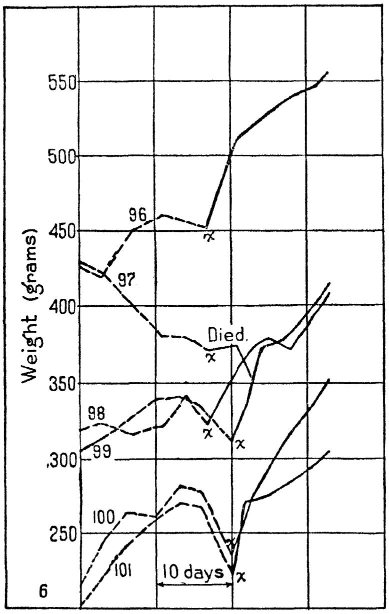
Fruits—Continued.
- Guayabano; *Anona muricata* Linn.
- Ates; *Anona squamosa* Linn.
- Mandarin; *Citrus nobilis* Lour.

Leafy vegetables:
- Alugbati; *Basella rubra* Linn.
- Kankóng; *Ipomea reptans* Linn.
- Pechay; *Brassica chinensis* Linn.
- Saluyot; *Corchorus olitorius* Linn.
- Lettuce; *Lactuca sativa* Linn.
- Sili; *Capsicum frutescens* Linn.
- Kolites; *Amaranthus viridis* Linn.
- Mustard; *Brassica integrifolia* (West) O. E. Schulz.
- Pakó; *Athyrium esculentum* Copel.

Table 1 gives the vitamin C content of these various fruits and leafy vegetables.

Sixty healthy guinea pigs were used in this investigation. They were fed ad libitum with a basal ration consisting of the following:

| Material. | Per cent. |
|---|---|
| Rice | 51 |
| Rice bran | 8 |
| Skim-milk powder | 30 |
| Butter fat | 10 |
| Sodium chloride | 1 |



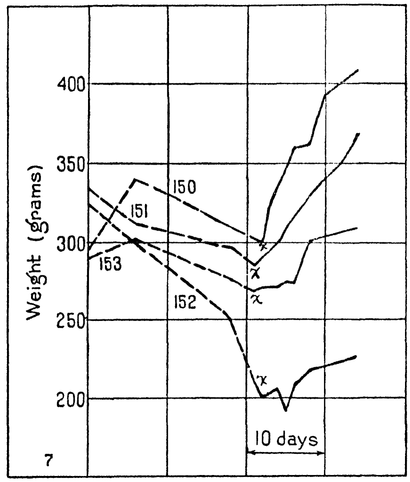
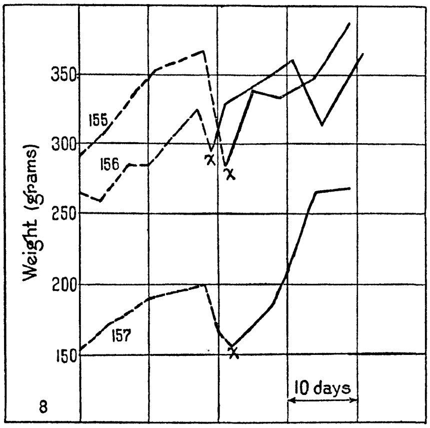




FIG. 6. Guinea pigs 96, 97, 98, 99, 100, and 101 were fed with the basal diet until scurvy was produced. From the point X, pigs 98, 99, 100, and 101 each received daily 7 cubic centimeters of mango, pico variety, in addition to the basal diet. No. 96 received 8 cubic centimeters of mango; No. 97 received 6 cubic centimeters and died. Pico mango is an excellent source of vitamin C.

FIG. 7. Guinea pigs 150, 151, 152, and 153 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 5 cubic centimeters of mandarin orange in addition to the basal diet. Nos. 150 and 151 responded promptly to the treatment, and Nos. 152 and 153 were slow. Mandarin orange is an excellent source of vitamin C.

The rice was boiled, dried at 110° C. for three hours, and then powdered. The skim-milk powder was previously heated at 110° C. for three hours. In addition to the basal ration, the animals were given hay previously heated at 110° C. for three hours and sufficient artesian well water. The guinea pigs were fed with this diet until the symptoms of scurvy were produced.

We found that most of our experimental animals would not eat sliced fruits. Consequently the pulp was cut into small pieces and ground thoroughly in a porcelain mortar. It was then squeezed through cheesecloth to make a homogeneous mixture of juice and pulp. The mixture was given daily to each guinea pig by means of a pipette placed in the mouth. Weighed quantities of the fresh leafy vegetables were given to each guinea pig in amounts shown in Table 1 and in text figures 8 to 16.



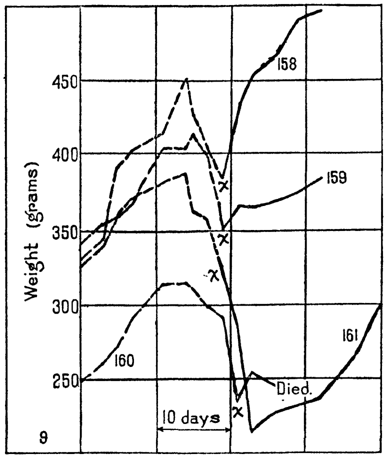
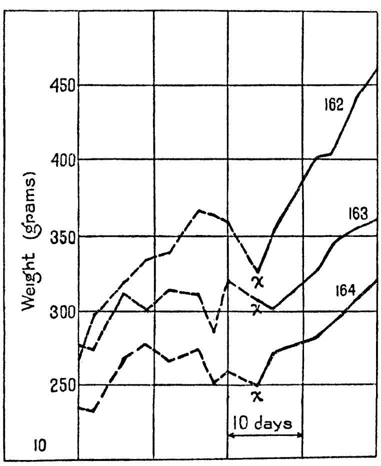




FIG. 8. Guinea pigs 155, 156, and 157 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of alugbati in addition to the basal diet. Alugbati was found to be an excellent source of vitamin C.

FIG. 9. Guinea pigs 158, 159, 160, and 161 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of sili leaves and tender shoots in addition to the basal diet. Guinea pigs 158 and 161 showed quick recovery, No. 159 was slow, and No. 160 died. Chile leaves were found to contain vitamin C.



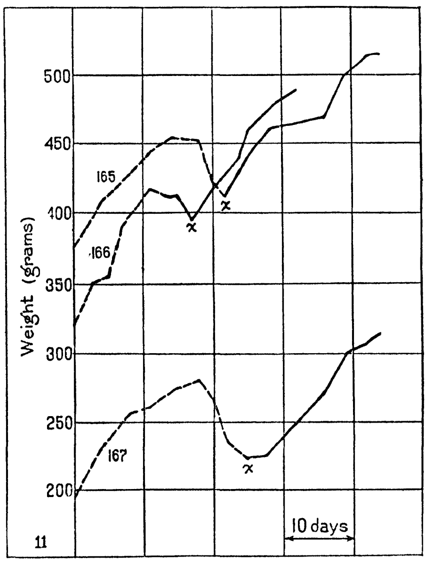




FIG. 10. Guinea pigs 162, 163, and 164 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of kankong leaves and tender shoots in addition to the basal diet. Kankong was found to be an excellent source of vitamin C.

FIG. 11. Guinea pigs 165, 166, and 167 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of kolites leaves and tender shoots in addition to the basal diet. Kolites was found to be an excellent source of vitamin C.

TABLE 1.—*Experimental data of various fruits and vegetables.*

| Serial No. | Common names. | Scientific name. | Natural family. | Used to supplement or cure. | | Average daily gain in weight. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | | Part of plant. | Amount. | | |
| | FRUITS | | | | cc. | g. | |
| 1 | Sugarapple, ates, atit | *Anona squamosa* Linn. | Anonaceæ | Strained pulp and juice of matured ripe fruits. | 10 | 4.74 | An excellent source of vitamin C. |
| 2 | Guayabano, guanabano, gabano. | *Anona muricata* Linn. | do | do | 8 | 4.21 | An excellent source of vitamin C. |
| 3 | Lanzon, lansones | *Lansium domesticum* Correa. | Meliaceæ | do | a 10 | 2.15 | Contains vitamin C. One guinea pig died. |
| 4 | Mango, mangá, páho, mangang-carabao. | *Mangifera indica* Linn. | Anacardiaceæ | do | 6 | 4.98 | A very potent natural source of vitamin C. |
| 5 | Mango, mangá, páho, mangang-pico. | do | do | do | 7 | 7.14 | Do. |
| 6 | Naranjita, mandarin, sintones, darogis. | *Citrus nobilis* Lour. | Rutaceæ | do | 5 | 5.19 | A very potent source of vitamin C. |
| | VEGETABLES | | | | g. | | |
| 7 | Alugbáti, libáto, grana, arogbáti. | *Basella rubra* Linn. | Basellaceæ | Leaves and tender shoots. | 10 | 5.15 | An excellent source of vitamin C. |
| 8 | Chile, sili, katumbal, kitikot, chileng-bundok. | *Capsicum frutescens* Linn. | Solanaceæ | do | 10 | 5.06 | The leaves contain vitamin C. Two pigs responded immediately, one responded after four days treatment, and the other died. |
| 9 | Kankóng, tangkong, kangkong. | *Ipomea reptans* Linn. | Convolvolaceæ | do | 10 | 5.48 | An excellent source of vitamin C. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10 | Kolites, kulitis, kalunai, halom. | *Amaranthus viridis* Linn. | Amaranthaceæ | do | 10 | 5.26 | Do. |
| 11 | Lettuce, lechuga | *Lactuca sativa* Linn | Compositæ | Entire leaves | 10 | 4.44 | Do. |
| 12 | Mustard, mostaza | *Brassica integrifolia* (West) O. E. Schulz. | Cruciferæ | do | 10 | 3.31 | Contains no appreciable amount of vitamin C. Two guinea pigs did not recover. |
| 13 | Pako, pakó | *Athyrium esculentum* Copel | Polypodiaceæ | Tender leaves | 10 | 0.00 | Contains an insufficient amount of vitamin C. |
| 14 | Pechay, pechai, messay, selgas. | *Brassica chinensis* Linn | Cruciferæ | Entire leaves | 10 | 6.05 | An excellent source of vitamin C. |
| 15 | Saluyot, tagabang, pasau, pasau-na-haba. | *Corchorus olitorius* Linn | Tiliaceæ | Leaves and tender shoots. | 10 | 4.09 | Do. |

[a] Or 11 g.

An autopsy was made on each guinea pig that died during the experiments. All guinea pigs illustrated on Plate 1 had characteristic symptoms of scurvy showing this to be the cause of their death.

Results of our vitamin C experiment are given in Table 1. The text figures (1 to 16) demonstrate the biological tests on the guinea pigs.

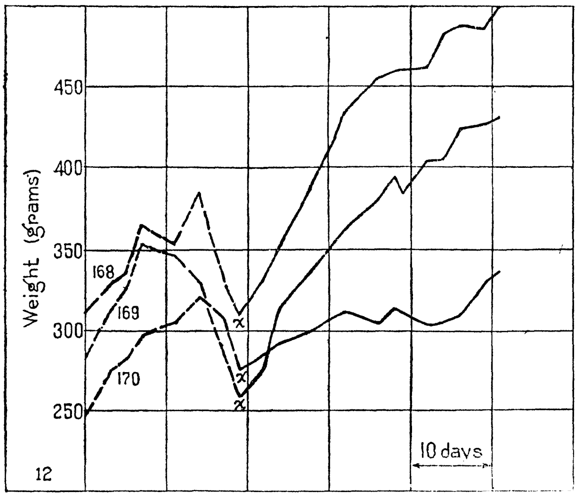
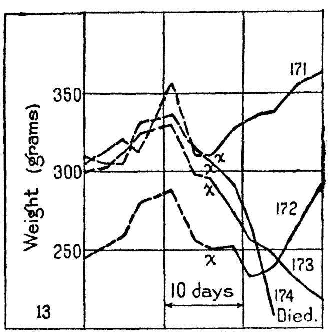



FIG. 12. Guinea pigs 168, 169, and 170 were fed with the basal ration until scurvy was produced. From the point X each guinea pig received daily 10 grams of lettuce leaves in addition to the basal diet. Lettuce was found to be an excellent source of vitamin C.



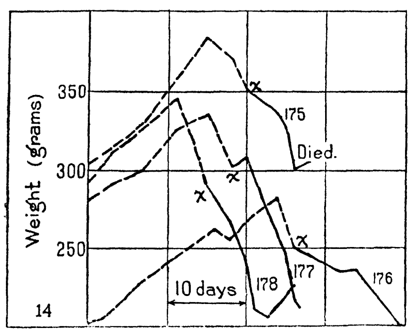




FIG. 13. Guinea pigs 171, 172, 173, and 174 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of mustard leaves in addition to the basal diet. Mustard leaves do not contain an appreciable amount of vitamin C.

FIG. 14. Guinea pigs 175, 176, 177, and 178 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of pakó leaves in addition to the basal diet. Pakó was found to contain an insufficient amount of vitamin C.

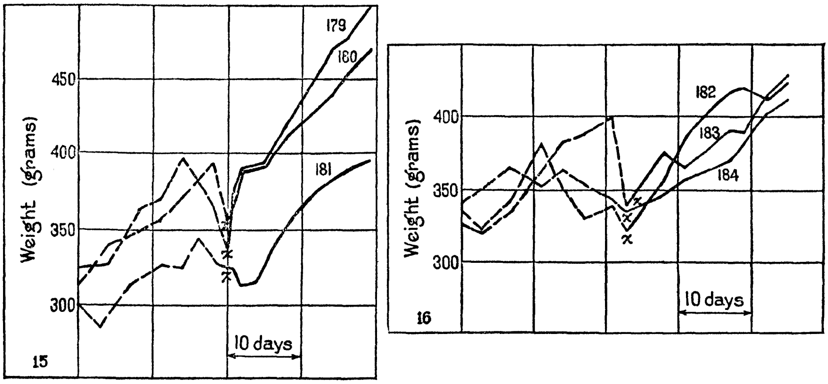



FIG. 15. Guinea pigs 179, 180, and 181 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of pechay leaves in addition to the basal diet. Pechay was found to be an excellent source of vitamin C since all the guinea pigs were cured of scurvy.

FIG. 16. Guinea pigs 182, 183, and 184 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of saluyot leaves and tender shoots in addition to the basal diet. Saluyot was found to be an excellent source of vitamin C.

## SUMMARY

As a result of our experiments it would seem that Philippine fruits and vegetables vary considerably in their vitamin C content.

Mangoes (carabao and pico varieties) and mandarin are potent natural sources of vitamin C. Guayabano and ates are also excellent sources of vitamin C; lansones are rather deficient.

Alugbati, kankóng, kolites, lettuce, saluyot, and pechay are excellent sources of vitamin C, and sili leaves contain a fair amount of vitamin C. Mustard has less vitamin C than sili but more than pako, which has an insufficient amount.

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# ILLUSTRATIONS

## PLATE 1

Guinea pigs with swollen jaws and lack of vigor are sick with scurvy.

## TEXT FIGURES

FIG. 1. Guinea pigs 1, 2, and 3 were fed with the basal diet. They all died after seventeen to twenty-four days of feeding.

2. Guinea pigs 68, 69, and 70 were fed with the basal diet until scurvy was produced. From the point X each animal received daily 10 cubic centimeters of atis in addition to the basal diet. All were cured of scurvy. Atis is an excellent source of vitamin C.

3. Guinea pigs 71, 72, 73, and 74 were fed with the basal diet until scurvy was produced. From the point X each animal received daily 8 cubic centimeters of guayabano in addition to the basal diet. All were cured of scurvy. Guayabano is an excellent source of vitamin C.

4. Guinea pigs 80, 81, 82, and 83 were fed with the basal diet until scurvy was produced. From the point X each animal received daily 10 cubic centimeters of lansones in addition to the basal diet. Three guinea pigs recovered very slowly and one died. Lansones contain vitamin C.

5. Guinea pigs 90, 91, 92, 93, 94, and 95 were fed with the basal diet until scurvy was produced. From the point X guinea pigs 90, 91, 92, and 95 each received daily 6 cubic centimeters of mango, carabao variety, in addition to the basal diet. No. 93 received daily from the point X, 7 cubic centimeters of mango and No. 94 received 8 cubic centimeters. All were cured of scurvy. Carabao mango is an excellent source of vitamin C.

6. Guinea pigs 96, 97, 98, 99, 100, and 101 were fed with the basal diet until scurvy was produced. From the point X guinea pigs 98, 99, 100, and 101 each received daily 7 cubic centimeters of mango, pico variety, in addition to the basal diet. No. 96 received 8 cubic centimeters of mango; No. 97 received 6 cubic centimeters and died. Pico mango is an excellent source of vitamin C.

7. Guinea pigs 150, 151, 152, and 153 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 5 cubic centimeters of mandarin orange juice in addition to the basal diet. Nos. 150 and 151 responded promptly to the treatment, and Nos. 152 and 153 were slow. Mandarin orange is an excellent source of vitamin C.

FIG. 8. Guinea pigs 155, 156, and 157 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of alugbati in addition to the basal diet. Alugbati was found to be an excellent source of vitamin C.

9. Guinea pigs 158, 159, 160, and 161 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of sili leaves and tender shoots in addition to the basal diet. Guinea pigs 158 and 161 showed quick recovery, No. 159 was slow, and No. 160 died. Chile leaves were found to contain vitamin C.

10. Guinea pigs 162, 163, and 164 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of kankong leaves and tender shoots in addition to the basal diet. Kankong was found to be an excellent source of vitamin C.

11. Guinea pigs 165, 166, and 167 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of kolites leaves and tender shoots in addition to the basal diet. Kolites was found to be an excellent source of vitamin C.

12. Guinea pigs 168, 169, and 170 were fed with the basal ration until scurvy was produced. From the point X each guinea pig received daily 10 grams of lettuce leaves in addition to the basal diet. Lettuce was found to be an excellent source of vitamin C.

13. Guinea pigs 171, 172, 173, and 174 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of mustard leaves in addition to the basal diet. Mustard leaves do not contain an appreciable amount of vitamin C.

14. Guinea pigs 175, 176, 177, and 178 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of pakó leaves in addition to the basal diet. Pakó was found to contain an insufficient amount of vitamin C.

15. Guinea pigs 179, 180, and 181 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of pechay leaves in addition to the basal diet. Pechay was found to be an excellent source of vitamin C since all the guinea pigs were cured of scurvy.

16. Guinea pigs 182, 183, and 184 were fed with the basal diet until scurvy was produced. From the point X each guinea pig received daily 10 grams of saluyot leaves and tender shoots in addition to the basal diet. Saluyot was found to be an excellent source of vitamin C.

PLATE 1.

# A SECOND RECORD OF A SOLENOSTOMID FROM THE PHILIPPINES [1]

By JOSÉ R. MONTILLA

*Of the Fish and Game Administration, Manila*

In June, 1932, while collecting living material for the Manila Aquarium, at Calapan, Mindoro, the writer obtained the following described specimen. It was taken in a "pukot," or fine-meshed native seine, along with pipefishes, rock-pilots, and other small species among the eelgrass in water about 1.5 meters in depth. It was received alive but survived only a short time. Because of its rarity it is herewith recorded.

## SOLENOSTOMIDÆ

Snout produced into a long tube. Body compressed, tail very short with long broad caudal fin. All parts covered with thin skin, below which is the dermal skeleton formed by large star-like ossifications. Mouth small, terminal. Spinous dorsal short; soft dorsal long and opposite to anal. Soft dorsal and anal fins on elevated bases; caudal fin long. Ventrals abdominal, and opposite the spinous dorsal, each of seven rays. They are free in the male, but the inner sides coalesce with the integument of the body to form a large pouch for the reception of the eggs in the female. Operculum well developed. Gill opening wide.

### SOLENOSTOMUS PHANTASTICUS Herre.

*Solenostomus phantasticus* HERRE, Copeia (April 3, 1933) 17.

Dorsal V, 17; anal 18; pectoral 26; ventral 7; depth $4\frac{1}{2}$ in length; head $2\frac{1}{2}$; eye $7\frac{2}{3}$ in head and $5\frac{2}{3}$ in snout; least height of snout about three times the length of the body. A blunt spine just in front of each eye, and two spines at the cristæ. Five spines, generally not well developed, on each side of the interorbital space. Opercle with distinct radiating ridges and armed with three spines. All tubercles developed into

[1] Contribution No. 3 from the Fish and Game Administration, Department of Agriculture and Commerce.

short, blunt spines. First ring around the body with nine spines. Second with ten spines and the third with fourteen. Twenty-six body rings present from just below first dorsal to caudal, each body ring with six spines. Second dorsal and anal fins elevated and each with four, short, blunt spines.

First dorsal rises from an elevated base; the length of the first dorsal base is 4 millimeters; that of second dorsal, 6, and of the anal, 6.

First dorsal spines 4 in length. Caudal peduncle comparatively slender; the least depth twice in its length. Height of caudal peduncle a little more than 2 in base of second dorsal. Dorsal and anal unbranched, and, like caudal and pectoral, extensive, rounded but short. Ventrals opposite spinous dorsal, very large with seven bifurcate rays. Skin provided with scattered, more or less visible, dermal prolongations, or villi which are branched in some places.

Color in life brown, with irregular, oblong, orange spots, each with a paler center. One series of these forms an irregular marking from eye to caudal. Spinous dorsal with large black blotches on membrane between first three spines. Other black blotches on first dorsal spines small; soft dorsal and anal mottled; caudal clouded with blackish.

The brown and black color remained unchanged in alcohol, but the irregular oblong spots of orange, each with a paler center, became white.

The above description is based on one specimen, a female, Fish and Game Administration No. 41044, 93 millimeters in total length, collected at Calapan, Mindoro, June 16, 1932.

Although members of the family Solenostomidæ have been previously recorded from Zanzibar, Mauritius, Maldives, Gulf of Manaar, Japan, Hawaii, and Ceram, this is the second record of this family and species in the Philippines.

This specimen agrees in most respects with *Solenostomus phantasticus* Herre; it differs chiefly in the depth of the body and in the natural coloring. The color of Herre's specimen was light red with many short stripes and cabalistic marking of deep maroon. Herre described the species from a single specimen, also female, 72 millimeters long, obtained in eelgrass at Dumaguete, Oriental Negros, Philippine Islands.

# OBSERVATIONS ON THE PHILIPPINE WEAVER, MUNIA JAGORI MARTENS, II: FOODS AND FEEDING HABITS[1]

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ONE TEXT FIGURE

## INTRODUCTION

The first paper of this series (1930) dealt with the breeding and associational habits of the Philippine weaver; the present one presents the food and feeding habits of the young and adult birds. These studies are necessary in order to determine the economic relation of this species of bird to agriculture and to enable us to furnish data for more adequate legislation on conservation.

The period of study may be divided into two parts, the materials studied in Los Baños between 1926 and 1928, and later observations extending to other places from June to November, 1932. Suspension of the studies between 1928 and 1932 was due to the writer's absence abroad.

## METHODS OF STUDY

Three methods of study were involved; namely, laboratory stomach examinations, field observations, and experiments with newly caged birds.

Up to 1928 the examinations of stomachs were made in the Department of Entomology, College of Agriculture, at Los Baños, while later laboratory studies were made in the division of zoölogy of the Bureau of Science, Manila. The materials studied up to 1928 were collected around Los Baños, particularly on the grounds of the College of Agriculture. Later collecting

[1] Contribution No. 4 from the Fish and Game Administration, Department of Agriculture and Commerce. The writer is under obligation to Dr. Leopoldo B. Uichanco, of the College of Agriculture, University of the Philippines, for suggesting this study; and to Dr. José B. Juliano, of the College of Agriculture, and to Mr. Edilberto Karganilla, of the Bureau of Science, for the identification of weeds.

was extended to Rizal, Laguna, Tayabas, Batangas, Cavite, Bulacan, Pampanga, Tarlac, and Nueva Ecija Provinces. Diverse types of ecological relations, open fields, both far from and near fresh and salt water, slopes, and valleys exist in the various localities covered by this study. All have representative samples. The birds were collected from rice fields as well as in places far from rice fields. From the rice fields they were obtained at different stages of the plant and before and after the rice season.

Examinations of the fæces of the birds were made in an attempt to determine whether or not the seeds pass through the system uninjured. In order to determine whether the seeds excreted were viable or not, the fæcal materials were sown in a seed box provided with sterilized soil.

To determine the maximum degree of the damage done by these birds to the rice crop, newly caged birds were fed with rice seeds in a Petri dish. The number of seeds given and the number left after feeding were recorded.

In order to determine whether the birds have any preference for a particular kind of food, seeds of rice of different stages of maturity, and of several varieties of weeds were offered at the same time to the caged birds. The seeds were given in panicles and placed in different places in the cage.

Studies dealing with the food of the young were superficial. In order to avoid killing the nestlings, samples were taken by slightly pressing the crop, and the kind and number of seeds noted.

The food materials recovered from the oral opening and from the gizzard of the adult birds were recorded and considered in the estimates. This portion of the digestive system is referred to as the stomach, for the food is generally recovered in the crop, proventriculus, and gizzard.

Both the "percentage by bulk"(4) and the "numerical"(4) systems of determining the amount of food were employed in this study. In the studies from 1926 to 1928 the "percentage by bulk system" was used; that is, the volume of each food item (rice seeds and the seeds of different varieties of weeds) was considered; in the later procedure the number of seeds of each food item recovered was noted.

Percentages are expressed in integers; fractions of less than one-half are considered as nil.

The significance of the results is expressed in the relation both of the individual bird and of the species as a whole to their food, and vice versa. The relation of the bird to the food is indicated by the average of the percentages of the different foods recovered in its stomach. The relation of the food to the bird is expressed in the percentage of the birds in a given lot and of all the birds studied that feed on certain foods.

Determination of the weed seeds recovered from the stomach was made principally by comparing them with the materials that were collected and preserved for this purpose. In the determination of the species of weed seeds, no high degree of accuracy is claimed; however, the rice seeds were carefully segregated from those of the uncultivated plants. Usually weed seeds were collected in places where the birds were feeding.

## RESULTS AND DISCUSSION

Much time was devoted to the examination of stomachs of adult birds. However, other means of studying the economic relation of the species were used.

### FOOD OF ADULTS

As the food of adult birds, to a large degree, determines the relation of this species to the rice crop, adult individuals were used in most of the laboratory observations reported in this paper.

*Stomach examination.*—Stomach examinations were recorded by month and place of collection. Estimates of the value of the bird (kind and amount of each food item and number of birds feeding on each) were made of each locality by month. Deviations from 100 per cent of the birds feeding on rice and weeds were due to the combination of these food items in a single stomach.

Studies dealing with the food habits of the weaver birds were started in December, 1926, when twelve birds were collected near a rice field at the experiment station of the College of Agriculture. It was estimated that about 29 and 71 per cent of the contents of their stomachs were rice and weed seeds, respectively. Sabung-sabuñgan [2] comprises the greater part of the food mak-

[2] A list of the common and scientific names of the plants the seeds of which were recovered in the stomachs of birds is given on page 417.

ing about 53 per cent by bulk. Laau-laau and tiribuhan were also recovered to the extent of 9 and 7 per cent, respectively. The balance of about 2 per cent was due to the presence in one stomach of amor seco. One stomach was empty. Rice seeds were obtained from three birds, weed seeds from eight.

In January, 1927, fourteen birds were obtained at the experiment station mentioned. At the time of collecting, the rice was being harvested and the birds were obtained in the field where they came at occasional intervals to feed on panicles of rice. Examination of the stomachs of this lot showed that, by volume, rice comprised about 80 per cent of the food, while about 20 per cent consisted of weeds, tiribuhan, and sabung-sabuñgan, representing about 15 and 5 per cent, respectively. Rice was recovered from thirteen stomachs, and weeds from eight.

Harvesting of lowland rice in the College Experiment Station continued until about the end of March, 1927, when the three birds in this lot were collected. The birds still show preference for rice over weed seeds, stomach examination showing about 87 per cent of the former grain and about 13 per cent of the latter. The weeds were tiribuhan and laau-laau. The seeds of both rice and weeds were found in all stomachs.

Collections were made during April, 1928, in a ratooned sugar-cane field of the College of Agriculture and in a rice field at Bay, both in Laguna Province, and in a rice field on the shore of Laguna de Bay at Angono, Rizal Province. Birds obtained from those three places were, fourteen from the grounds of the College of Agriculture, fifty from Bay, and sixteen from Angono. It was found that 58 per cent of the contents of the stomachs from the Agricultural College was rice, weeds making up the balance of 42 per cent. One stomach was empty, rice seeds were noted in ten stomachs, and weeds were obtained from six.

Examination of fifty stomachs collected at Bay resulted in the recovery of 84 per cent rice seeds and 16 per cent weed seeds from forty-nine of them; one stomach was empty. The bulk of weed seeds was tiribuhan, which constituted about 15 per cent. Seeds of sabung-sabuñgan, laau-laau and amor seco were also recovered. About 92 per cent of the birds collected fed on rice, as this grain was found in forty-six stomachs. Weed seeds were found in twenty-five stomachs representing 50 per cent of the birds in this lot.

One of the stomachs collected at Angono was empty. In those that contained food, rice and weed seeds constituted 98 and 2 per cent, respectively. Rice seeds were obtained from fifteen of sixteen birds, and tiribuhan was found in only two stomachs. About 94 per cent of the birds in this group had fed on rice, while about 13 per cent ate tiribuhan in addition.

Records from the three places named above indicate that the stomachs of seventy-seven birds collected in April, 1928, contained 79 per cent rice seeds and 21 per cent weed seeds, by volume. Rice seeds were recovered from seventy-one birds, representing about 89 per cent of the lot; weed seeds were obtained from thirty-three stomachs, representing about 41 per cent.

In May, 1928, twenty-two birds were obtained from the uncultivated grounds of the Agricultural College at Los Baños, Laguna Province. One stomach was empty. Of those with food, rice seeds constituted about 5 per cent of the contents while weed seeds represented slightly over 95 per cent. Of the weed seeds taken in this lot sabung-sabuñgan represented 70 per cent and tiribuhan 16 per cent. The remainder were seeds of luya-luyahan and laau-laau. Rice was recorded from three stomachs, or about 14 per cent of the birds collected. Weeds were recorded from twenty-one stomachs, or about 95 per cent of the birds.

The stomach contents of weavers collected at the Agricultural College Experiment Station, Los Baños, in June, 1928, largely consisted of weed seeds. From this place twelve birds were obtained at three different periods during the month. Volumetrically about 8 per cent of their food was rice seeds, and about 92 per cent was weed seeds. Of the weeds, sabung-sabuñgan comprised about 54 per cent, tiribuhan about 32 per cent, and luya luyahan and laau-laau combined about 5 per cent. Rice seeds were recorded from one stomach and weed seeds from all the stomachs. The volumetric method of determining the contents of the stomachs of one hundred thirty-one weavers, collected mostly around the College of Agriculture (Table 1) within a period of six months in three years, indicates that the birds are entirely grain-eating, rice representing 48 per cent, of their food and five species of weeds the balance of 52 per cent. Rice seeds were recorded from ninety-five of one hundred forty-three stomachs, showing that 66 per cent of the birds studied had fed on this grain.

TABLE 1.—*Value of Philippine weavers based on volumetric study of their foods.*

| Locality and condition. | Collecting spot. | Date. | Birds collected. | Percentage composition of food (volume). | | Percentage of birds feeding. | |
|---|---|---|---|---|---|---|---|
| | | | | Rice. | Weeds. | Rice. | Weeds. |
| Laguna, Agricultural College: Diversified crops in practice. | Rice field in head. | Dec., 1926 | 12 | 29 | 71 | 25 | 66 |
| Do | Harvested rice field. | Jan., 1927 | 14 | 80 | 20 | 93 | 57 |
| Do | do | Mar., 1927 | 3 | 87 | 13 | 100 | 100 |
| Agricultural College: Near buildings and small lots of sugar cane. | Ratooned sugar-cane field. | Apr., 1928 | 14 | 58 | 42 | 71 | 43 |
| Bay: Rice fields | Rice field in head. | Apr., 1928 | 50 | 84 | 16 | 92 | 50 |
| Rizal, Angono: Rice fields close to shore of Laguna de Bay. | do | Apr., 1928 | 16 | 98 | 2 | 94 | 13 |
| Laguna, Agriculture College: Near campus. Fruit trees around. | Citrus orchard | May, 1928 | 22 | 5 | 95 | 14 | 95 |
| Agricultural College: Diversified crops in practice. | Harvested rice field. | June, 1928 | 12 | 8 | 92 | 8 | 100 |

Weed seeds were taken from eighty-five stomachs. This is equivalent to 59 per cent of the birds feeding on this item. The results up to 1928 indicated that the bird was graminivorous, feeding on either rice seeds or weed seeds. The volume of the seeds remains proportionately constant to the number of seeds recovered. It was, therefore, thought best to change from the percentage by bulk to the numerical system. The actual number and the corresponding approximate volume were thus both indicated. An advantage of the numerical system is that by means of it can be recorded the presence of seeds too minute for accurate determination of their volume.

Actual collection of materials for stomach examination was resumed in July, 1932. Sixty stomachs, obtained from seven places in four provinces, were studied during that month. Ten stomachs were empty.

Ten birds were obtained in a rolling, open field at San Jose del Monte, Bulacan Province. One stomach was empty; nine contained weed seeds with a preponderance of sabung-sabuñgan. Numerically this weed composed about 6 per cent of the food taken from the stomachs of weavers in this lot. Batad-batádan and laau-laau constituted 16 and 17 per cent, respectively. Tiri-

buhan formed about 7 per cent, while three seeds of amor seco represented an insignificant percentage of the food recovered from this lot.

Seven birds were collected from Novaliches, Rizal Province, in two periods during the month. Examination of their stomachs indicated that they had fed wholly on weeds, amor seco occupying about 42 per cent numerically. Other weeds recovered were laau-laau sabung-sabuñgan, and batad-batádan.

In Tanay, Rizal, twenty-five birds were collected from one spot at one time. Nothing was recovered from nine of them. Of the recovered food, weed seeds formed about 96 per cent numerically. Sabung-sabuñgan was the heaviest item, representing about 80 per cent. Tiribuhan represented about 14 per cent. Laau-laau was the other weed obtained. Rice seeds comprised about 4 per cent of the food. The data show that 28 per cent of the birds collected in Tanay took rice seeds, and 40 per cent weed seeds.

Stomach contents of fourteen weavers collected in an open, rolling field newly planted to rice at Maketipo, Rizal Province, consisted entirely of weed seeds. Except in one stomach where six seeds of sabung-sabuñgan were obtained, laau-laau and amor seco either alone or in combination were found in all the stomachs examined.

The stomachs of two birds collected at Tungkong Manga, Bulacan Province, one from Los Baños, Laguna Province, and another from Amadeo, Cavite Province, contained weed seeds.

Fifty birds from seven places in four provinces yielded 33 rice seeds and 5,879 weed seeds distributed as follows: tiribuhan, 272; sabung-sabuñgan, 2,146; laau-laau, 2,399; amor seco, 757; and batad-batádan, 305. Numerically, the rice seeds comprised slightly less than 1 per cent. Rice seeds reported for this month were obtained from seven of twenty-five stomachs collected near a newly harvested rice field in Tanay, Rizal Province. The data indicate that about 12 per cent of the birds collected had fed on rice seeds and about 73 on weed seeds.

During August, 1932, Philippine weavers were collected in eleven places in three provinces.

The first group was obtained in Biñan, Laguna Province. In three places in this municipality forty-six birds were collected either in the rice field when the rice was ripe, close to the field, or about 5 kilometers from it.

Of thirteen stomachs collected far from the rice field one was empty and the food of twelve birds was largely weed seeds, only

two rice seeds having been secured from one stomach. Tiribuhan and laau-laau were the principal food items. In one stomach 704 seeds of tiribuhan were noted, while 588 seeds of laau-laau were taken from another. Sabung-sabuñgan and amor seco were recorded to a less extent.

Collecting in the rice field yielded results of a different nature. Of the thirteen stomachs examined, one was empty. A total of 392 rice seeds obtained from eleven stomachs comprised 24 per cent. Laau-laau, daua-dauahan, and amor seco were recovered from seven stomachs.

The data obtained from the birds collected near a rice field made the results from two other places named above more interesting. Two of the twenty stomachs collected from this place were empty. Rice seeds taken from ten stomachs comprised about 6 per cent. Three stomachs had nothing but rice seeds. A mixture of rice and weed seeds was noted in seven of them. Amor seco was the principal food item. Other weeds were tiribuhan, laau-laau, daua-dauahan, luya-luyahan, and sabung-sabuñgan. Weed seeds were noted in fifteen stomachs of this lot.

Numerically, rice and weed seeds comprised about 9 and 91 per cent, respectively, in this lot. Birds collected from the rice field tend to feed more on rice, while weeds constitute almost the entire food of those obtained away from a rice field; those secured near a rice field take both rice and weed seeds in amounts proportionate to the distance from the corresponding sources of food. Records from these three places of varying conditions show that twenty-two individuals, or about 48 per cent of the birds, collected in Biñan had taken rice seeds, while thirty-four individuals, or about 74 per cent, fed on weeds.

From a vacant rice field near Los Baños, Laguna Province, forty-two weavers, mostly young of the year, were obtained. The place of collection was about 300 meters from the nearest rice field where rice was in head. The birds, obviously coming to drink, congregated in drying carabao wallows.

Weeds constituted the entire food of the birds in this lot, with tiribuhan making up about 91 per cent and amor seco about 8 per cent. Other weed seeds, representing less than 1 per cent, were laau-laau and daua-dauahan.

Ten birds from a vacant rice field in Pila, Laguna Province, fed largely on weed seeds, according to the findings from their stomachs. In one stomach were recorded 10 seeds of rice and 58 of sabung-sabuñgan. A total of 826 seeds of tiribuhan, constituting about 80 per cent of the food, was obtained. Luya-

luyahan was recorded in one stomach. Rice seeds comprised about 1 per cent of the food of the birds in this lot. From this group one individual, or 10 per cent of the birds, had rice seeds in the stomach. Weeds were recovered from all of them.

In Candelaria, Tayabas Province, thirty-seven weavers were obtained in a rice field where the crop was in head. Flocks of this bird visited the field early in the morning and late in the afternoon. One flock that alighted in a rice field contained approximately seven hundred birds. Thirty-six stomachs contained 1,425 rice seeds, either alone or in combination with weed seeds. Numerically, rice seeds constituted about 35 per cent of the food recovered. The seeds of daua-dauahan, 1,723 seeds from twenty-four stomachs, outnumbered those of all other weeds combined, and represented about 42 per cent of the birds' food. During observation in this place the panicles of this species of weed were noted to overgrow those of the rice and this condition probably accounts for this weed's seeds being more numerous than those of rice, although the birds were collected in an extensive rice field. About this weed Quisumbing(10) states, "Some farmers purposely allow such grass to grow side by side with rice, and it is said to drive the birds away, because of the long awns of the spikelets, and thus protect their rice fields from the attack of birds." The effects of this weed on the rice crop, as indicated by Quisumbing, appear to agree with the trend of results obtained in this study, in that it saves the grain from the attacks of weaver birds. His statement, however, presents an entirely different view in so far as the cause of protection of the crop is concerned. It seems likely that the bird's preference for the seeds of the weed was the cause of less damage to the cultivated crop. Other seeds recovered were laau-laau and amor seco to the extent of about 15 and 8 per cent, respectively. The results from this lot show that thirty-six birds, or about 97 per cent, of the group fed on rice, while weed seeds were recovered from twenty-nine individuals, or about 80 per cent.

From Mauban, Tayabas Province, about 5 kilometers from the shore of the Pacific Ocean, in a small valley newly planted to rice, sixteen weavers were collected. Except in one stomach where 1 rice seed was obtained with 24 seeds of batad-batádan and 540 of tiribuhan, all of the birds collected had fed on weed seeds. The rice formed an insignificant part of 2,627 seeds recovered from the stomachs of this lot. These results indicate

that only 6 per cent of the birds had taken rice seeds, while weed seeds were obtained from all the stomachs.

In a large rice field in Lucban, Tayabas Province, seventy-one birds were obtained in two days. Collecting was done in the morning and in the afternoon when the birds were noted to feed on rice grains. Three stomachs were empty.

Rice seeds to the number of 756 were recovered from forty-three stomachs, representing about 8 per cent of the food recorded. Weeds consisting of eight species comprised about 92 per cent of the food by number. As in the samples from Candelaria, daua-dauahan outnumbered the other species of weeds combined. This weed constituted about 62 per cent of the entire food obtained. Tiribuhan, amor seco, and sabung-sabuñgan constituted about 12, 7, and 6 per cent, respectively. Laau-laau, batad-batádan, *Cyperus* sp., and kabit-kabit represented the balance of 5 per cent.

About 61 per cent of the birds took rice seeds. Weeds were recovered from sixty-one stomachs, or about 86 per cent, of the birds in this lot.

Near an upland rice field in Balayan, Batangas Province, seven birds were collected August 25. In their stomach contents 64 rice seeds constituted about 20 per cent, 164 seeds of tiribuhan about 53 per cent, 81 seeds of amor seco 26 per cent, and 6 seeds of sabung-sabuñgan less than 1 per cent.

Five, about 71 per cent, of the birds of this lot had fed on rice seeds, while all devoured weeds belonging to either one or a combination of the three species named above.

While the grain was in head in a rice field near Lemery, Batangas Province, five weavers were shot in the act of feeding. Rice seeds constituted about 2 per cent, numerically, of the stomach contents. Daua-dauáhan made up the balance of about 98 per cent. Rice seeds were recovered from two of the birds, and daua-dauáhan from four.

In Tanauan, Batangas, twelve weavers were shot in an upland rice field when the grain was in head. Two stomachs were empty. From seven birds 118 rice seeds were obtained, representing about 23 per cent of the food recovered. With a preponderance of laau-laau, constituting about 46 per cent, four species of weeds were noted. The other species were tiribuhan, *Cyperus* sp., and amor seco, about 16, 10, and 5 per cent, respectively. Weed seeds were recovered from five stomachs. In this lot 58 per cent of the birds fed on rice seeds, while about 42 per cent ate weed seeds.

The food of the Philippine weaver in August, deduced from a study of 246 individuals collected in eleven places in three provinces, numerically, was 11 per cent rice seeds and 89 per cent weed seeds. About 48 per cent of these birds had fed on rice seeds, and about 85 per cent on weed seeds.

Studies in September, 1932, were confined to two days collecting in the neighborhood of Los Baños, Laguna, in a vacant rice field near fields where rice was in head.

Twenty-one birds were obtained in this lot. One stomach was empty. Rice seeds constituted about 1 per cent of the food. Weed seeds represented about 99 per cent. The largest item was 2,915 seeds of tiribuhan, about 78 per cent. Amor seco and batad-batádan constituted about 17 and 4 per cent, respectively.

Rice seeds were obtained from ten stomachs, or about 48 per cent; weed seeds from seventeen stomachs, or about 81 per cent of the birds.

Studies for October, 1932, were made in Bulacan, Pampanga, Nueva Ecija, and Tarlac Provinces, which are extensive rice-growing regions in the Central Plain of Luzon.

In Bulacan Province the birds were collected from the municipalities of Pulilan, Quiñgua, Baliuag, Bustos, San Rafael, and San Ildefonso.

In Pulilan twenty-one birds were obtained October 2 and 3 in an uncultivated place about 5 kilometers from the nearest rice field. One stomach was empty, and from the rest 14,357 seeds of weeds belonging to ten species were recorded. Amor seco was the largest item noted with 11,228 seeds. Other weeds obtained were daua-dauahan, sabun-sabuñgan, agiñgai, tiribuhan, laau-laau, katábad alitbañgun, *Cyperus* sp., and batad-batádan.

In an open field at Quiñgua, where there were various crops (sweet potato, corn, rice, etc.), forty-six weavers were collected October 5. That the rice was in the flowering stage perhaps explains the absence of this grain in the stomachs of the birds examined. A total of 25,782 seeds of weeds belonging to thirteen species were recorded. The largest of these items was 21,854 seeds of amor seco. Sabung-sabuñgan and daua-dauáhan were represented by 2,017 and 1,445 seeds, respectively. Other weeds noted were *Cyperus* sp., agiñgai, tiribuhan, laau-laau, katábad, bocaui, luya-luyáhan, *Phyllanthus simplex*, batad-batádan, and iba-ibá-an.

Collecting in Makinabang, Baliuag, at two different periods yielded twenty-seven stomachs. The place was far from any field of rice in head. This perhaps explains the recovery of only fourteen seeds of this grain in two stomachs, representing a negligible fraction of the 18,215 seeds recorded from this lot. Amor seco made up about 88 per cent and sabung-sabuñgan about 5 per cent. Other weeds recorded were daua-dauáhan, agiñgai, alitbañgun, *Cyperus* sp., batad-batádan, and laau-láau. All stomachs from this lot contained weed seeds, and about 7 per cent had rice seeds.

October 4 and 7 thirty-six birds were obtained in Baliuag, about 4 kilometers from a field of rice in head. The food recovered from twenty-seven of these birds was calculated to consist of about 6 per cent rice seeds and 94 per cent weed seeds. The other stomachs were empty. Representing about 66 per cent of the food noted were 1,821 seeds of amor seco. Other weed seeds taken were tiribuhan, sabung-sabuñgan, daua-dauáhan, luya-luyáhan, laau-láau, katábad, and *Cyperus* sp. Rice seeds were recorded from twelve stomachs, and weed seeds from twenty-four stomachs.

In the afternoon of October 15, in a rice field by the river at Bustos, eighteen birds were taken. The stomachs of eleven were empty. From four stomachs twelve rice seeds were recorded, comprising about 44 per cent of the food recovered. Sabung-sabuñgan and luya-luyáhan noted in four stomachs made up the balance of about 56 per cent.

At San Rafael twenty-eight birds were collected near a rice field with grain in head. One stomach was empty. Rice seeds recovered from twenty-three stomachs constituted about 16 per cent of the contents. Weed seeds recorded from twenty-three stomachs constituted about 84 per cent. The largest item in this lot was 509 seeds of sabung-sabuñgan, representing about 30 per cent of the food. In one stomach were 477 seeds of agiñgai, representing about 28 per cent of the entire food. Other seeds were katábad, amor seco, laau-láau, *Cyperus* sp., and tiribúhan.

Four weavers were collected from a field of rice not in head at San Ildefonso. One stomach was empty. From three stomachs were recovered 21 seeds of katábad, 17 of sabung-sabuñgan, and 3 of tiribúhan, respectively.

One hundred seventy-six weavers were obtained from seven places in Bulacan Province. Rice seeds constituted about 9 per cent of the food and weed seeds 91 per cent.

About 24 per cent of the birds (42 individuals) collected had fed on rice seeds and about 84 per cent of the lot (148 birds), on weed seeds.

In Pampanga Province five birds were obtained from Apalit when they alighted in a field of rice in head. One stomach was empty. Rice seeds in three stomachs comprised about 45 per cent of the food by number, while sabung-sabuñgan and daua-dauáhan in each of two stomachs made up 55 per cent.

In Tarlac Province twenty-three birds were obtained from three places during two days of collecting.

From the Municipality of Tarlac eighteen birds were collected October 18 and 19. From three of them no food was recovered. Rice seeds in three stomachs constituted about 3 per cent of the food. Seeds of six species of weed made up the balance. Daua-dauáhan was represented by 346 seeds constituting about 48 per cent. Other weeds noted were amor seco, sabung-sabuñgan, kolatai, agiñgai, and laau-láau. Weeds were noted in fifteen stomachs.

In a rice field at San Miguel three birds were taken. Fifty-four rice seeds, representing 55 per cent of the food, were recovered from two stomachs. Daua-dauáhan and amor seco were found in three stomachs.

The food of two birds from a rice field in Murcia was studied. Rice seeds made up 73 per cent of the food in both stomachs. Amor seco from one stomach filled the balance of 27 per cent.

Cabanatuan, Talavera, Santa Rosa, and Gapan, in Nueva Ecija, were visited for this study.

Five days collecting in an open field at Cabanatuan yielded forty-five birds. The places of collection were almost uniform as far as general ecological conditions were concerned. The nearest fields of rice in head were 5 kilometers distant. Three stomachs were empty. Of the contents of forty-two stomachs the rice seeds obtained from seven birds constituted less than 1 per cent. Weeds consisting of nine species made up the balance of slightly over 99 per cent. Tiribuhan and amor seco were represented by 5,043 and 3,737 seeds, respectively. Daua-dauáhan, sabung-sabuñgan, luya-luyáhan, alitbañgun, kabit-

kabit, *Cyperus* sp., and laau-láau were the other items noted. Weeds were recorded from forty stomachs.

October 10 two birds were shot in Talavera. Neither stomach contained anything but seeds of tiribúhan; one contained 240 and the other 273 seeds.

From Santa Rosa, where the birds were noted in a rice field, twenty-six stomachs were examined. Four were empty. From three stomachs eighteen seeds of rice were noted, representing less than 1 per cent. With a preponderance of amor seco, amounting to about 97 per cent, slightly over 99 per cent consisted of weeds belonging to ten species—amor seco, sabung-sabuñgan, daua-dauáhan, laau-láau, *Cyperus* sp., alitbañgun, katábad, batad-batádan, pásau-na-bilog, and kolatai. The weed seeds were noted in twenty-two stomachs.

In a field of rice in head at Gapan, Nueva Ecija, five weavers were obtained October 12. Thirty-seven rice seeds found in four stomachs constituted about 8 per cent of the food recovered from this lot. Daua-dauáhan obtained from one stomach represented about 76 per cent of the food. Amor seco was also present. Weeds were noted in two stomachs.

The food of eighty-seven weavers from Nueva Ecija consisted of 2.5 per cent rice seeds and 97.5 per cent weed seeds. Fourteen individuals, or about 18 per cent of the birds collected, had eaten rice; 66 individuals, or about 85 per cent, had fed on weeds.

The study of 282 weavers during October, 1932, in fifteen places in four provinces of the Central Plain shows that rice seeds constituted about 25 per cent of the food, and sixteen species of weed made up about 75 per cent.

Rice seeds were obtained from sixty-six stomachs, representing about 23 per cent of those collected during the month. Weed seeds from two hundred thirty-five individuals comprised about 83 per cent.

In November, 1932, while the rice crop in the vicinity was being harvested, collections of material for this study were made in Maketipo and Novaliches, both in Rizal Province, on the 23d and 25th, respectively. In six birds obtained from a patch of cogon, *Imperata cylindrica* Linn., at Maketipo, four stomachs contained about 7 per cent rice seeds. With amor seco outnumbering others, seeds belonging to six species of weeds were obtained from four stomachs. They were, besides amor seco,

daua-dauáhan, kolatai, *Cyperus* sp., batad-batádan, and kabit-kabit.

From a rice field in Novaliches, thirteen stomachs of weavers were studied. Rice seeds from eleven of them constituted about 28 per cent of the food recovered. Two stomachs were empty. Amor seco, kolatai, sabung-sabuñgan, *Cyperus* sp., and batad-batádan in varying amounts made up the balance of about 72 per cent. They were taken from eight stomachs.

Of the stomachs of nineteen birds collected in two neighboring places in November, when rice was in head, fifteen contained rice seeds constituting about 14 per cent of the food recovered. Weeds belonging to seven species were found in twelve stomachs, making up the balance of about 86 per cent.

Of the food of 628 Philippine weavers (Table 2), from thirty-six collecting places in nine provinces (fig. 1), from July to November, 1932, numerically, rice seeds constituted about 3 per cent and the seeds of at least eighteen species of weeds about 97 per cent. About 34 per cent of the birds collected had eaten rice seeds, while about 82 per cent had eaten weed seeds.

Field observations and stomach examination of the birds collected within this period have shown that among the weeds the species most abundant in any given locality is preferred by the birds. In collecting the materials studied, the places were not selected. Birds were shot wherever seen. Inasmuch as a large percentage of weed seeds was recovered from the stomachs, even if they were obtained from rice fields, it may be concluded that the birds preferred the weeds to rice.

The aggregate of the results obtained in two periods of study involving the volumetric and the numerical methods, respectively, of determining the amount of food taken, has been expressed in common by estimating the relation between the volumes of the seeds of rice and those of the different species of weeds noted.

Estimates based on actual measurement of their volume give the following number of seeds to occupy 1 cc of water: 63 rice, about 600 tiribúhan, about 800 daua-dauáhan, and about 1,900 amor seco. The volume of the seeds of fifteen other weeds was assumed to be the same as that of tiribúhan.

At this rate, 3,864 seeds of rice could be displaced by 62.66 cc; 62,113 seeds of amor seco by 32.16 cc; 12,855 seeds of daua-dauáhan by 16 cc; 21,657 seeds of tiribúhan by 36 cc and

TABLE 2.—*Value of Philippine weavers based on a numerical study of their foods.*

| Locality and condition. | Collecting spot. | Date. | Birds collected. | Percentage composition of food (numerical). | | Percentage of birds feeding. | |
|---|---|---|---|---|---|---|---|
| | | | | Rice. | Weeds. | Rice. | Weeds. |
| Bulacan, San Jose del Monte: Rolling open field | Cogonal | July, 1932 | 10 | -------- | 100 | -------- | 100 |
| Tungkong Manga: Open field | Vacant rice field | July, 1932 | 2 | -------- | 100 | -------- | 100 |
| Rizal, Novaliches: Vacant rice fields and uncultivated fields | do | July, 1932 | 7 | -------- | 100 | -------- | 100 |
| Tanay: Association of tikiw along the shore; corn in head; rice newly harvested. | Open shore of Laguna de Bay | July, 1932 | 25 | 4 | 96 | 28 | 40 |
| Maketipo: Rolling field; rice newly transplanted | Vacant rice field | July, 1932 | 14 | -------- | 100 | -------- | 100 |
| Cavite, Amadeo: Hilly, uncultivated field | Cogonal | July, 1932 | 1 | -------- | 100 | -------- | 100 |
| Laguna, Agricultural College: Near campus | Lawn | July, 1932 | 1 | -------- | 100 | -------- | 100 |
| Biñan: Grass association; newly plowed rice fields around | Grass association | Aug., 1932 | 13 | -------- | 100 | 8 | 92 |
| Biñan: Rice field, some are yet in head, others have been harvested. | Rice field; rice in head | Aug., 1932 | 13 | 24 | 76 | 82 | 53 |
| Biñan: Open field, about 5 km from nearest rice field | Vacant rice field | Aug., 1932 | 20 | 6 | 94 | 50 | 75 |
| Los Baños: Vacant rice fields; rice in head; coco groves | do | Aug., 1932 | [a] 42 | -------- | 100 | -------- | 100 |
| Pila: Vacant rice field; newly planted rice, coco groves, etc | do | Aug., 1932 | 10 | 1 | 99 | 10 | 100 |
| Tayabas, Candelaria: Rice fields, coco groves, citrus orchards, etc. | Rice fields, rice in head | Aug., 1932 | 37 | 35 | 65 | 97 | 80 |
| Mauban: Grassland, rice at young stage in the valley, coco groves on hills, sides and tops. | Open grassland | Aug., 1932 | 16 | -------- | 100 | 6 | 100 |
| Lucban: Extensive rice fields, grain in head | Rice field | Aug., 1932 | 71 | 8 | 92 | 61 | 86 |
| Batangas, Balayan: Upland rice fields; sugar-cane fields; bamboo thickets, etc. | Small corn field near rice in head | Aug., 1932 | 7 | 20 | 80 | 71 | 100 |
| Lemery: Road side, rice field and brush | Rice field, grain in head | Aug., 1932 | 5 | 2 | 98 | 40 | 80 |
| Tanauan: Hilly extensive cultivated lands; diversified crops in practice. | do | Aug., 1932 | 12 | 23 | 77 | 58 | 42 |
| Laguna, Los Baños: Vacant rice fields; rice in different stages | Rice field, rice in head | Sept., 1932 | 21 | 1 | 99 | 48 | 81 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bulacan, Pulilan: Open field, vacant rice field, rice field grain not in head. | Vacant rice field | Oct., 1932 | 21 | | 100 | | 100 |
| Quingua: Open field; diversified crops in practice | In rice field grain not in head | Oct., 1932 | 46 | | 100 | | 100 |
| Baliuag, District of Makinabang: Immediate surroundings planted to a variety of crops; rice not in head. | Vacant rice field | Oct., 1932 | 27 | | 100 | 7 | 100 |
| Baliuag: Diversified crops in practice; rice in head nearby | Corn field | Oct., 1932 | 32 | 6 | 94 | 38 | 74 |
| Bustos: Near a river, brush; rice field nearby | Vacant rice field | Oct., 1932 | 18 | 44 | 56 | 22 | 22 |
| San Rafael: Rice fields, grain in head | do | Oct., 1932 | 28 | 16 | 84 | 82 | 82 |
| San Ildefonso: Vacant rice fields at a distance | do | Oct., 1932 | 4 | | 100 | | 100 |
| Pampanga, Apalit: Rice fields, grain in head; few vacant rice fields. | Rice field | Oct., 1932 | 5 | 45 | 55 | 60 | 40 |
| Tarlac, Tarlac: Open field, cogonal; rice in different stages | Cogonal | Oct., 1932 | 18 | 3 | 97 | 17 | 83 |
| San Miguel: Rice fields, grain in head; few vacant paddies | Rice field | Oct., 1932 | 3 | 55 | 45 | 67 | 100 |
| Murcia: Rice in head and uncultivated fields | do | Oct., 1932 | 2 | 73 | 27 | 100 | 50 |
| Nueva Ecija, Cabanatuan: Rice fields, grain in head nearby; vacant rice fields at intervals. | do | Oct., 1932 | 45 | 1 | 99 | 16 | 89 |
| Talavera: Open rice fields; grain in head | do | Oct., 1932 | 2 | 0 | 100 | 0 | 100 |
| Santa Rosa: Rice fields; grain in head at a distance | do | Oct., 1932 | 26 | 1 | 99 | 12 | 94 |
| Gapan: Rice fields; vacant fields at intervals | do | Oct., 1932 | 5 | 8 | 92 | 80 | 40 |
| Rizal, Maketipo: Rolling field; rice in harvest, etc | Cogonal | Nov., 1932 | 6 | 7 | 93 | 66 | 66 |
| Novaliches: Rice in harvest | Rice field | Nov., 1932 | 13 | 28 | 72 | 85 | 62 |

[a] These birds, mostly young, came in numbers presumably to drink from nearly dried pools.

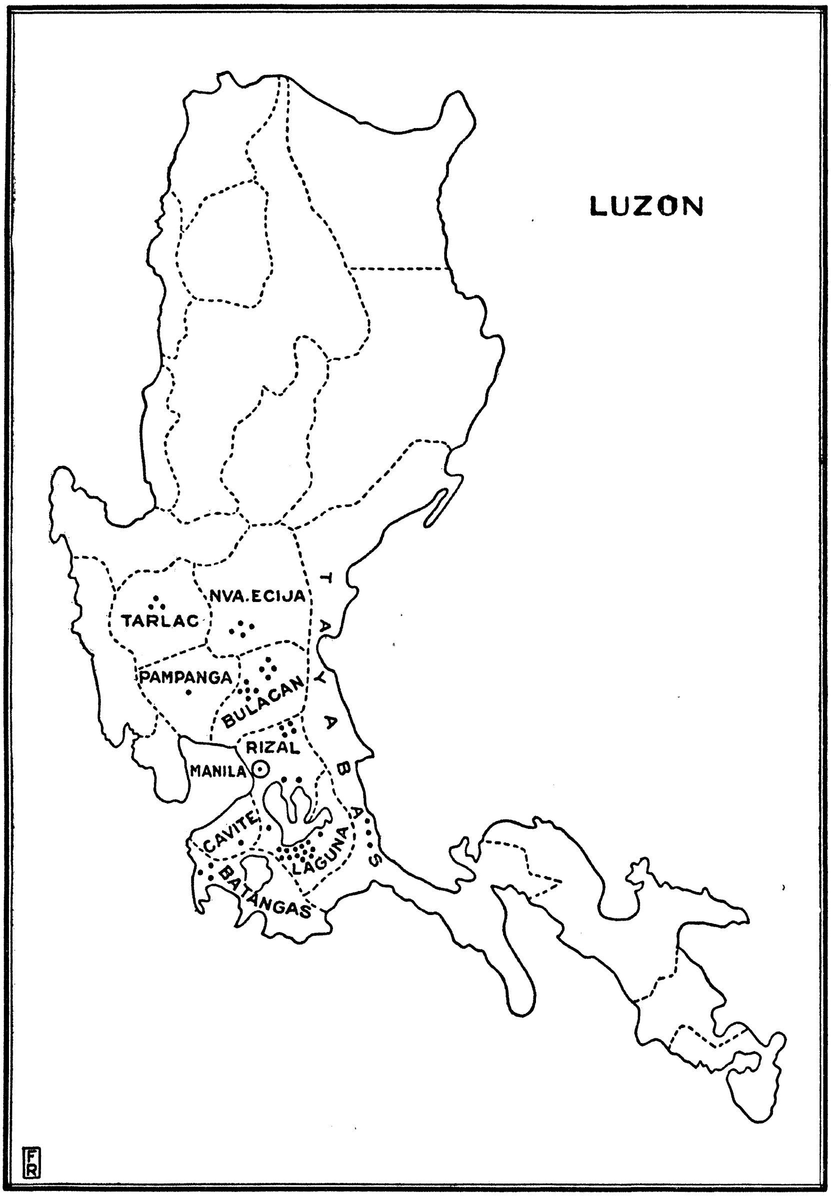


FIG. 1. Luzon, showing where Philippine weavers were collected.

the balance of 11,775 seeds of 15 other species of weeds by 19.6 cc. Therefore the percentages by volume of the food recovered during the five months of study are as follows: 3,868 rice seeds, 43; 118,400 weed seeds, 57.

These figures show a slight difference from those obtained during the first six months of study when 48 and 52 per cent of rice and weed seeds, respectively, were noted. The difference may partly be due to errors in measuring the volume of the different seeds recovered.

### FOOD OF NESTLINGS

During the period of study eighteen nestlings were observed in their haunts at occasional intervals. Observations were made from the time they were hatched until they either died or left the nest. Due to the fact that male and female birds are indistinguishable, especially from a distance, it was not ascertained whether or not the adults take turns in feeding the nestlings.

Food was offered in the form of pellets and feeding generally took place in the morning and in the afternoon. Seed of weeds constituted the food of all the young observed. Although the number of seeds noted was not accurately determined, there was observed a difference in amount at various periods during the nesting season. A general proportionate increase of the number taken with the age was noted. It was roughly estimated, however, that a daily average of about three hundred weed seeds was fed to each nestling for about eighteen days. Considering that four young are hatched from a set of eggs, as the writer has pointed out,(8) and the inability of some of them to reach the flying stage, it is conservatively estimated that a daily destruction of about 1,000 seeds of weeds by the occupants of a single nest takes place. This will mean about 18,000 seeds during the nesting period. If it could be demonstrated that this number represents a check to the weed population, the benefit derived from this species of bird during the breeding season can further be estimated by noting the writer's observation to the effect that within an area of about 1,250 square meters, thirty-two nests were built among the citrus trees at one time.

### FEEDING HABITS OF PHILIPPINE WEAVERS: THEIR EFFECT ON THE FOOD PLANT

The food of weavers has been found to be seeds of rice and weeds. Due, perhaps, to the fact that material was collected mostly in open fields, the observations of Roxas(11) that this

species of bird picked caterpillars of *Pericyma cruegeri* (Butler) was not verified by this study.

*Food preference.*—Stomach examinations showed that the greater percentage of the food of the Philippine weavers consisted of weed seeds. Preference for weed seeds becomes more obvious upon inspection of collecting grounds. In the collection of the birds wherever seen the greater number was obtained outside of rice fields. These are indications of the birds' preference for weed seeds to those of rice. An attempt to prove these results was made in the laboratory. Caged birds were given panicles of rice (milky and mature seeds) and those of amor seco, daua-dauáhan, tiribúhan, and laau-láau. After a series of five days of observation the birds preferred the seeds in the following order: Tiribúhan, amor seco, daua-dauáhan, milky rice seeds, laau-láau, and mature rice seeds. If this result be considered as occurring in nature, the percentage of rice seeds taken by the weavers would be greater than the estimate presented in this paper, as the milky rice seeds were not recovered in the stomachs included in the calculations.

*Effect of the birds to the rice crop.*—In the examination of the stomach contents of 628 weavers, a minimum of 1 and a maximum of 88 rice seeds were found. The extent of the damage done by this species, particularly to rice crops, will be an important contribution of this investigation. Generally accepted beliefs, including those of Camus(2) and Teodoro(12) concur as to the destructive effects of the species. It should be noted that all the figures obtained represent only one feeding time and do not indicate the possibility of the maximum extent of the value of the species to the plants fed upon. The stomachs of a few individuals contained 100 per cent rice seeds, but whether these birds feed exclusively on this grain throughout the day is not known. In order to approximate the number of seeds a bird destroys in one day, assuming that some of them feed wholly on this grain during the rice season, a series of experiments giving caged Philippine weavers a certain number of rice seeds throughout the day, was conducted. The grain was offered both to single and to paired birds. On the average, 178 and 174 rice seeds were taken by single and paired birds, respectively, during a period of twenty-four hours. The difference may have been due to the time spent by the paired bird in cooing, playing, or in driving away its mate from the Petri dish. The possibility of devouring more seeds under na-

tural conditions due to increased appetite caused by muscular exertion might be expected. Also, the birds may find it easier to pick the seeds from a panicle than from a dish. On the other hand, occasional disturbance during feeding, artificial devices to scare the birds and uncertainty of food supply will tend to limit the amount eaten. These two opposing factors may be considered as neutralizing each other.

The significance of these results appears better from the consideration that by actual count a liter was found to contain 25,480 rice seeds of the same variety as those fed to the birds. At the rate of 174 seeds a day (gregariousness of birds considered) it will take about 146 birds to consume a liter of rice seeds in one day or about 146 days for one bird to utilize the same amount. If the birds could have their full quota, 438 individuals could consume a ganta of rice seeds in one day. Uninterrupted visits of large flocks will certainly result in considerable damage to the crop. This estimate involves only the mature grain and does not take into account the crop in the milk stage which is considered by many as the state most heavily damaged by the birds. Although the result of experiments, described above, tends to confirm this belief actual field observations did not corroborate the accusation.

*Effect of the bird on the weeds.*—The data show that weed seeds are the preponderant food of the Philippine weavers. It is interesting to observe that as many as 3,624 seeds of amor seco, 808 of daua-dauáhan, 752 of tiribúhan, 672 of laau-láau, and 235 of sabung-sabuñgan were counted in one stomach. In addition, the number fed to thousands of young each year must be very great. The aggregate of weed seeds consumed by the species in one year is, undoubtedly, incalculable.

In Iowa, Beal(1) estimated that the annual consumption of one species of sparrow amounts to 875 tons of weed seeds. Whether the amount of seeds destroyed by the birds is a check to the yearly weed crop is not known. The tremendous amount of weed seeds produced each year, however, is too great to make the number destroyed by the birds of any significant value. In this connection Judd's(7) remarks are of interest. He states, "A single plant may mature as many as a hundred thousand seeds in a season, and if unchecked would produce in the third year ten billion plants." He refers to the effect of seed-eating birds as a control of this enormous increase. If the weavers hold the weed crop to a certain limit, there will also be

an effect on the population of the rice bug, which according to Uichanco(13) harbors temporarily on these plants until the rice attains the suitable stage for the insect. Quisumbing (1923) made the same observation.

*Viability of voided materials.*—It is generally conceded that birds are effective agents in the dispersion of plants. This has an important bearing on this study, for, if the Philippine weaver is an agent of dispersal of the enormous amount of weed seeds it takes every year, besides the damage to the rice crop, the species has, excepting its esthetic value, everything against it, and Dammerman's(5) contention that this belongs to a group of the most destructive birds could be reiterated herewith.

Six birds were placed in three cages, a pair in each. In each cage panicles of tiribúhan, sabung-sabuñgan, laau-laáu and amor seco were placed in the morning and left during the day. In the afternoon clean sheets of Manila paper were placed directly under the cages and left over night. The operation was repeated with rice seeds instead of weeds. The series was repeated four times. Droppings were collected at night and examined the following morning. There was not a whole seed found in the droppings. This result agrees with that of Judd,(7) who observed the habits of sparrows in the United States fed with different species of weeds.

The procedure was repeated by placing a seed box with sterilized soil under the cage instead of Manila paper. Nothing germinated in the seed box, indicating that Philippine weavers are not responsible for the dispersion through their fæces of any of the weeds tried in this experiment. Unfortunately, this result does not agree with the findings of Collinge,(3) who, working on the house sparrow, greenfinch, and bullfinch, was able to cultivate the weeds he obtained from the droppings of the bird. Harvey(6) was able to germinate the seeds of Virginia creeper obtained from the excrement of the English sparrow in Colorado, U. S. A. Pycraft(9) found that *Munia* aided considerably in the dispersal of adhesive seeds carried on the birds' wings.

## SUMMARY

1. Owing to the fact that valuable results concerning the food habits of birds are obtained through stomach examination of adult birds, the greater part of the time in this investigation was spent on this method of study. The foods recovered are

expressed in percentages. The percentage of the birds feeding on both rice and weed seeds was also estimated.

2. Adult individuals were used in all the laboratory experiments reported in this paper.

3. Estimates of the value of the bird were grouped by places and by months. Final accounting was based on all birds studied.

4. The results of six months' study (December, 1926; January, March, 1927; April, May, and June, 1928) of 143 Philippine weavers, expressed volumetrically, are indicated in Table 1 and show that on the average 48 per cent rice seeds and 52 per cent weed seeds constitute the food of adult weavers.

5. Basing the estimate on the birds collected during this period, 66 per cent of the weavers feed on rice while 59 per cent feed on weeds. Except at one time, when the materials were obtained at Angono, Rizal Province, the specimens used during the period of study were collected in and around the College of Agriculture at Los Baños, Laguna Province.

6. Because of the almost uniform kind and size of seeds recovered from the stomach studied, the method employed in later examinations was changed from the volumetric to the numerical system.

7. The results of five months' study (July, August, September, October, and November, 1932) of 628 weavers, obtained in 36 collecting grounds belonging to 9 provinces, are shown in Table 2.

8. The final account shows that 3 per cent of the birds' food was rice seeds and 97 per cent was weed seeds. Converting these figures into terms of volume, the value becomes approximately 43 per cent rice and 57 per cent weed seeds.

9. Numerically, the four heaviest weeds recovered are amor seco, tiribúhan, daua-dauáhan, and sabung-sabuñgan.

10. Of the 628 individuals studied 35 per cent of the birds feed on rice, while 82 per cent feed on weed seeds.

11. The presence of daua-dauáhan in the rice fields saves the rice crop from the destruction of Philippine weavers, due probably to the birds' preference for this weed over rice.

12. Birds collected in rice fields when the grain is in head, generally feed largely on the seeds of this plant; those obtained away from such places feed extensively on weed seeds.

13. Evidence from collecting grounds, stomach contents, and laboratory experiments indicates that the birds prefer weeds

to rice. In the laboratory the seeds were preferred by the birds in the following order: tiribúhan, amor seco, daua-dauáhan, milkly rice seeds, laau-laáu, and mature rice seeds.

14. During the milk stage of the rice, the weavers were not observed to alight on the crop.

15. The food of weaver nestlings consists exclusively of weed seeds.

16. As many as eighty-eight seeds of rice were recorded from the stomach of an adult weaver. This represents only one feeding.

17. The average daily consumption of each bird, based on laboratory conditions, amounts to 174 mature rice seeds. At this rate it will take about 146 days for one bird to consume 1 liter of hard rice seeds or about 146 weavers to finish 1 liter in one day. Uninterrupted visits of large flocks will cause considerable damage.

18. As many as 3,624 seeds of one species of weed were recovered from one bird. This represents a record for only one feeding. The number of seeds destroyed annually by this species must be very great.

19. The weed seeds eaten by the birds probably represent a negligible part of the annual crop. Except where the birds may be a check on the excessive spread of weeds, the Philippine weaver may be considered of neutral importance as far as the weed item is concerned.

20. Seeds of tiribúhan, sabung-sabuñgan, laau-laáu and amor seco fed to the weavers were not recovered in the fæces. Planting of fæcal materials did not show that the seeds fed were viable.

## CONCLUSIONS

This study indicates that the Philippine weaver is entirely a seed-eating bird, seeds of rice and weeds constituting its food. The species feeds, to a large extent, on weed seeds, and conditions being equal, prefers this food to the seeds of rice. Rice seeds constitute a small percentage of the food of the Philippine weavers studied, but some birds obtained in rice fields when the grain was in head fed largely on this grain. The prevailing methods of repelling the birds when the crop is in head should be encouraged as the Philippine weavers may turn their feeding activities entirely to the weed seeds. The young and adults feed chiefly on weed seeds during the nesting season. A large amount of weed seeds being destroyed by the Philippine weavers

does not appear significant, considering the tremendous annual crop.

The species is, therefore, harmful to a certain degree when the rice is in head, but otherwise of neutral importance.

*List of food plants of Philippine weavers.*

Gramineæ:
- Rice; *Oryza sativa* Linn.
- Agiñgai (Tag.); *Rottboellia exaltata* Linn.
- Amor seco (Tag.); *Andropogon aciculatus* Retz.
- Batad-batádan (Tag.); *Andropogon halepensis* (Linn.) Brot.
- Laau-laáu (Tag.); *Paspalum conjugatum* Berg.
- Tiribúhan (Tag.); *Panicum colonum* Linn.
- Daua-dauáhan (Tag.); *Panicum crus-galli* Linn.
- Sabung-sabuñgan (Tag.); *Panicum lavidum* Retz.
- Luya-luyáhan (Tag.); *Panicum repens* Linn.
- Agiñgai (Tag.); *Cenchrus viridis* Spreng.
- Kabit-kabit (Tag.); *Eleusine indica* (Linn.) Gaertn.
- Kolatai (Tag.); *Cynodon dactylon* Peters.
- Bocaui (Tag.); *Schizostachyum lumampao* (Blco.) Merr.

Cyperaceæ:
- *Cyperus* sp.
- Katábad (Tag.); *Scleria tessellata* Willd.

Euphorbiaceæ:
- *Phyllanthus simplex* Retz.
- Ibaibá-an (Tag.); *Phyllanthus urinaria* Linn.

Tiliaceæ:
- Pásau-na-bilog (Tag.); *Corchorus capsularis* Linn.

Commelinaceæ:
- Alitbañgun (Tag.); *Aneilema malabaricum* (Linn.) Merr.

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# ILLUSTRATION

TEXT FIG. 1. Luzon, showing where Philippine weavers were collected.

# DIE CALLIRRHIPIS-UNTERGATTUNG HELLERIOLA EMDEN, 1931 (COLEOPTERA; SANDALIDÆ)

## ZUR KENNTNIS DER SANDALIDÆ 20; ZUGLEICH PHILIPPINISCHE SANDALIDÆ 3

Von Fritz van Emden

*Dresden, Deutschland*

Die Umgrenzung der Untergattung gab ich in den Entomologischen Blättern,[1] doch ist von den drei dort genanten Arten, den einzigen mir bekannten diese Gruppe, bisher keine beschrieben. Nachstehend veröffentliche ich diese drei Arten. Als Typus soll *Helleriana* m. gelten.

Die Unterschiede der Untergattung von *Callirrhipis* s. str. (Fühlerlamellen, wenigstens von der des 6. Gliedes ab, weniger als sechsmal so lang wie das zugehörige Glied) sind auffällig genug, und es würde kaum jemand versuchen, die beiden ersten Arten bei *Callirrhipis* unterzubringen. In praktischer Hinsicht ist also die Abtrennung dieser Artengruppe sicher erwünscht, da die Tiere das Bild von *Callirrhipis* s. str. zu sehr verwischen würden, wenn man sie dabei liesse. Auch der Habitus und die Skulptur der drei Arten sind verwandt. Dennoch ist es fraglich, ob die Gruppe durchaus natürlich ist, da der vordere Stirnteil bei den beiden anderen Arten abweichend gebaut ist und mit dem der *trepida*-Gruppe übereinstimmt, während er sich bei *Helleriana* an die *dissimilis*-Gruppe anschliesst. Gegen eine gar zu nachdrückliche Wertung dieses Merkmals spricht immerhin die Tatsache, dass sich darin auch das Männchen von *Callirrhipis helleri* Schultze, nicht jedoch das Weibchen—wenn ich dieses richtig bestimmt habe—und beide Geschlechter von *C. scutellata* Frm. wie die Mehrzahl der Callirrhipini verhalten, während ihre übrigen Merkmale kaum einen Zweifel an der Zugehörigkeit zur *trepida*- bzw. *lineata*-Gruppe aufkommen lassen. Ausser letzeteren beiden Gruppen und *Helleriola henrikeni* und *laticornis* weist nur *Zenoa picea* Pal. den ausgeschnittenen Vorderteil der Stirn auf.

[1] Ent. Blätt. 27 (1931) 51.

*Bestimmungstabelle der Arten.*

1(2). Der vor den Fühlerhöckern befindliche Teil der Stirn plattenförmig vorgezogen und Clypeus und Oberlippe überdeckend. Halsschild ziemlich fein und wenig dicht punktiert. Präscutellareindrücke miteinander verflossen, doch nach aussen scharf abgegrenzt. Hauptpunktierung der Flügeldecken ziemlick fein, vier bis fünf Punkte bilden eine unregelmässige Querreihe. Die Fühlerlamellen vom 4. Glied ab wenig mehr bis weniger als zweimal so lang wie das zugehörige Glied. 2. bis 4. Tarsenglied höher als lang. Mindanao ........ *helleriana* sp. nov.

2(1). Der vor den Fühlerhöckern befindliche Teil der Stirn fällt steil ab und ist breit halbkreisförmig ausgerandet, Clypeus und Oberlippe frei. Halsschild wenig fein bis grob, sehr dicht punktiert. Präscutellareindrücke flach oder tief, in der Mittellinie jedoch sehr deutlich getrennt. Hauptpunktierung der Flügeldecken ziemlich grob, zwei bis drei Punkte bilden eine unregelmässige Querreihe.

3(4). Tarsen schlank, 2. und 4. Glied länger als hoch. Fühlerglieder ziemlich lang, Lamellen kurz, die des 4. Gliedes weniger als dreimal so lang wie das zugehörige Glied. Präscutellareindrücke klein und wenig tief, voneinander durch die auch an der Basis nicht niedergedrückte sondern gewôlbte Umgebung der Mittellinie sehr deutlich, von den übrigen Eindrücken wenig auffällig getrennt. Behaarung ziemlich lang, anliegend, am Seitenrand der Flügeldecken von vor der Mitte an struppig abstehend. Sumatra. *henrikseni* sp. nov.

4(3). Tarsen weniger schlank, das 2. und 4. Glied etwas höher als lang. Fühlerglieder mässig lang, die Lamellen ziemlich gross, besonders die basalen, die des 4. Gliedes fast achtmal, die des 6. etwa fünfmal, die des 10. etwa dreimal so lang wie das zugehörige Glied. Präscutellareindrücke sehr gross und tief, voneinander und von den übrigen Eindrücken durch breite, stark erhabene Wülste getrennt. Behaarung anliegend und ziemlich kurz, besonders auf dem grössten Teil der Flügeldecken, am Seitenrand der letzteren regelmässig nach hinten gekrümmt, kurz und ziemlich anliegend. Borneo ........ *laticornis* sp. nov.

**CALLIRRHIPIS (HELLERIOLA) HELLERIANA sp. nov.**

Männchen; Mindanao, Kolambugan; Baker, Typus Mus. Dresden. Schwärzlich graubraun, wenig lang anliegend graugoldgelb behaart, Fühler, Schienen und Tarsen dunkel rotbraun, Taster rotbraun. Die Behaarung etwas unregelmässig gelagert, ohne jedoch eine merkliche Scheckung zu erzeugen. Kopf mässig dicht, ziemlich grob und tief punktiert. Zweites und drittes Kiefertasterglied gleich lang, um einhalb länger als breit, das letzte fast doppelt so lang, zweimal so lang wie breit. Fühler dreiviertel so lang wie der Körper, das 3. Glied fast zwei und dreiviertelmal, das 4. reichlich viermal, das 10. reichlich fünfmal so lang wie dick, die Lamelle des 3. Gliedes fast zwei und

dreiviertelmal, die des 10. Gliedes fast ein und dreiviertelmal so lang wie das zugehörige Glied, das 11. Glied flach nach innen gebogen, so lang wie das 10., 9. und die reichliche Hälfte des 8. zusammen. Halsschild breit, die vordere Hälfte kräftig und ziemlich gleichmässig gerundet, die Seiten ziemlich flach aber sehr deutlich ausgerandet, der Seitenrandeindruck selbst jedoch sehr schwach, die Seiten vor den Hinterecken geradlinig und fast parallel, nur sehr schwach nach hinten divergierend. Die herabgeschlagenen Vorderecken als gerundete Augenlappen verhältnismässig kräftig vorgezogen, bei binokularer dorsaler Betrachtung eben zu bemerken. Halsschildpunktierung wenig fein, ziemlich tief, etwas ungleichmässig, wenig dicht, die Zwischenräume nahe der Mitte etwas ölig verfliessend. Discoidaleindruck klein und tief, Präscutellareindrücke gross und tief, miteinander vershmolzen, doch nach aussen scharf begrenzt, Hintereckeneindruck gross und ziemlich tief. Halsschild in den apikalen drei Fünfteln flach und gleichmässig gewölbt, vor der Basis abgeflacht. Schultern wenig breiter als die Halsschildbasis, sehr flach gerundet. Die Flügeldecken bis fast ans Ende des 3. Fünftels leicht gerundet sehr schwach erweitert, von da zur Spitze in sehr flacher Rundung verengt, am Ende abgerundet-sugespitzt. Die Rippen wenig scharf begrenzt, breit und flach erhaben, die 1. endet frei, die 2. vereinigt sich mit dem Ende der 4., die 3. nur hinter der Schulter ein kurzes Stück deutlich, unter der Schulter aus der Basis der 4. entspringend, die Vereinigung der Rippen endet ziemlich weit vor der Spitze frei. Die Fläche zwischen den Rippen leicht konkav und stellenweise etwas geknittert. Hauptpunktierung der Flügeldecken ziemlich fein und wenig dicht, es bilden vier bis fünf Punkte eine unregelmässige Querreihe, zwischen je zwei Punkten haben ein bis drei weitere Platz. Grundpunktierung ziemlich fein und wenig dicht, leicht runzlig verbunden. Flügeldecken im Basaldrittel mässig gewölbt, im mittleren Drittel fast geradlinig, im Enddrittel erst schwächer, dann stärker abwärts gewölbt, der Breite nach mässig gewölbt. Schienen mässig schlank, die Hinterschienen in der Mitte leicht eingebogen, Tarsen wenig schlank, das 2. bis 4. Tarsenglied höher als lang, das Klauenglied schon im Basaldrittel breiter als die vorhergehenden Glieder. Länge 15,5, Schulterbreite 4,5, Fühlerlänge 12 mm.

Ausser den in der Tabelle angegebenen Merkmalen durch bedeutendere Grösse, viel längere Fühler, mehr graubraune Färbung und das Fehlen eines vollständigen Haarwirbels in den

Basaleindrücken der Flügeldecken von den beiden anderen Arten auffällig abweichend.

**CALLIRRHIPIS (HELLERIOLA) HENRIKSENI sp. nov.**

Vier Männchen, Sumatra: Si-Rambé 12. 1890–3. 1891, E. Modigliani, Mus. Kopenhagen (davon ein Mus. Dresden) (Cotypen); Männchen, Sumatra, Solok, P. O. Stolz (Mus. Leyden) (Cotypus); Männchen, Sumatra, Loeboe Raja, A. L. v. Hasselt, Mus. Leyden (Cotypus).

Dunkel rotbraun, Taster, Fühler, Schienen und Tarsen rotbraun. Behaarung goldgelb, wechselnd gelagert, eine leichte Scheckung erzeugend, ziemlich lang, anliegend, jedoch am Seitenrand der Flügeldecken in den distalen drei Fünfteln struppig abstehend, in den Basaleindrücken der Flügeldecken sternförmig gelagert, also einen Wirbel bildend. Kopf wenig dicht, tief und wenig grob punktiert. Drittes Glied der Kiefertaster fast so lang wie das 2., ein Viertel länger als breit, letztes spindelförmig zugespitzt und etwas nach innen gebogen. Fühler zwei Drittel bis drei Viertel (0,65–0,74 so lang wie der Körper, das 3. Glied zwei und ein Viertel bis swei und drei Viertelmal, meist fast genau zwei und ein halbmal, das 4. drei und ein halb bis viermal, das 10. etwa vier und ein halbmal so lang wie dick, die Lamelle des 3. Gliedes dreimal, die des 10. zweimal so lang wie das zugehörige Glied, das 11. Glied flach gerundet nach innen gebogen, wenig kürzer als das 8. bis 10. zusammen. Halsschild kurz und breit, flach halbkreisförmig gerundet, die Rundung vor der Mitte infolge der schmalen und wenig auffälligen Seitenrandeindrücke etwas abgeflacht oder leicht ausgerandet, vor der Basis fast geradlinig oder (Solok) schwach gerundet etwas erweitert. Die herabgeschlagenen Vorderecken als gerundete Augenlappen ziemlich kräftig vorgezogen, bei binokularer dorsaler Betrachtung deutlich sichtbar. Halsschildpunktierung wenig fein, ziemlich tief, dicht und gleichmässig. Discoidaleindrücke ziemlich gross und ziemlich tief, nach hinten-aussen breit mit den grossen Hintereckeneindrücken verfliessend. Präscutellareindrücke klein und wenig tief, voneinander durch die auch an der Basis nicht niedergedrückte sondern gewölbte Umgebung der Mittellinie sehr deutlich, von den übrigen Eindrücken nur breit, flach und wenig auffällig getrennt. Halsschild in den basalen zwei Dritteln eben, zur Spitze wenig stark abwärts gewölbt, der Breite nach sehr flach gewölbt. Schultern deutlich breiter als die Halsschildbasis, breit gerundet, Flügeldecken bis ans Ende des 1. Drittels ganz schwach verengt,

fast parallel, von da bis ans Ende des 2. Drittels ebenso schwach erweitert, zur Spitze in flacher Rundung stark verengt, am Ende spitz abgerundet. Die inneren Rippen durch die sie reihig begleitende Hauptpunktierung gut begrenzt, doch kaum merklich erhaben, die 1. mündet in die 2. oder endet frei, die 3. und 4. meist undeutlich, sich mehr oder weniger undeutlich miteinander und dann mit der Verlängerung der 1. und 2. verbindend, die gemeinsame Verlängerung aller Rippen mündet deutlich oder undeutlich nahe der Spitze in die Naht. Die Fläche zwischen der 2. Rippe und der Naht, in wenig deutlichem Masse auch die zwischen der 2. und 3. Rippe stellenweise konkav, besonders hinter der Mitte mit einigen fast grübchenförmigen Eindrücken. Hauptpunktierung der Flügeldecken ziemlich grob und dicht; es bilden zwei bis drei Punkte eine unregelmässige Querreihe; zwischen je zwei Punkten hat meist nur oder kaum ein weiterer Platz. Grundpunktierung mässig fein und ziemlich zerstreut bis wenig dicht. Flügeldecken im Basaldrittel schwach bis mässig gewölbt, im übrigen fast geradlinig und nur zur Spitze leicht gerundet abfallend. Schienen schlank, die Hinterschienen gegen die Mitte schwach eingebogen. Tarsen schlank, alle Glieder länger als hoch, besonders das, 1. Glied, dieses vor allem an den Vordertarsen sehr schlank, aber selbst an den Hintertarsen noch fast dreimal so lang wie hoch. (Bei ein Stück von Si-Rambé sind beide Vorderbeine symmetrisch unverhältnismässig verkürzt aber normal gegliedert und nur weniger schlank. Es handelt sich wahrscheinlich um Regenerate von auf frühem Larvenstadium verlorengegangenen Extremitäten. Das symmetrische Auftreten braucht dem bei der eng benachbarten Einlenkung der kurzen Larvenbeine nicht zu widersprechen.) Länge 10 bis 12, Schulterbreite 3,0 bis 3,5, Fühlerlänge 7,2 bis 8,6 mm.

Von der folgenden Art besonder durch viel schlankere Gestalt und viel kürzere Fühlerlamellen des Männchens auffällig unterschieden.

CALLIRRHIPIS (HELLERIOLA) LATICORNIS sp. nov.

Männchen, Borneo, Museum für Naturkunde, Stettin (Typus).—Dunkel rotbraun, Taster, Fühler, Schienen und Tarsen hell rotbraun, Behaarung der Flügeldecken verschieden gelagert, eine leichte Scheckung erzeugend. Kopf wenig dicht und wenig grob punktiert. Zweites und drittes Kiefertasterglied gleich lang, so lang wie breit, das 4. swei und ein halbmal so lang wie das 3. und ebenso breit. Fühler reichlich drein Fünftel so

lang wie der körper, das 3. Glied anderthalbmal, das 4. etwa zweimal, das 10. viermal so lang wie dick, die Lamelle des 3. Gliedes reichlich neunmal, die des 10. dreimal so lang wie das zugehörige Glied, das 11. Glied an der Spitze etwas eingebogen, etwa so lang wie das 7. bis 10. Glied zusammen. Halsschild sehr kurz und breit, die vordere Hälfte sehr breit und gleichmässig gerundet, die Seiten sehr tief ausgerandet, der Seitenrandeindruck kräftig, die Seiten zu den Hinterecken kräftig gerundet. Die herabgebogenen Vorderecken als gerundete Augenlappen stark vorgezogen, bei binokularer dorsaler Betrachtung deutlich erkennbar. Halsschildpunktierung grob, tief, ziemlich dicht, etwas unregelmässig, die Zwischenräume jederseits der Mitte etwas querrunzlig verfliessend. Discoidaleindrücke wenig gross und mässig tief, Präscutellareidrücke gross und sehr tief, voneinander und von den anderen Eindrücken sehr scharf getrennt, Hintereckeneindrücke gross und wenig tief. Halsschild in den apikalen zwei Fünfteln ziemlich stark gewölbt, dahinter flach und leicht konkav abfallend. Schultern wenig breiter als die Halsschildbasis, ziemlich flach gerundet. Flügeldecken hinter den Schultern flach und breit ausgeschweift, bis ans Ende des 3. Fünftels leicht erweitert, von da zur Spitze in sehr flacher Rundung verengt, am Ende schmal abgerundet-zugespitzt. Die Rippen kaum merklich gewölbt, in der Hauptsache durch das Fehlen der Hauptpunktierung erkennbar, die 1. endet frei, die 2. vereinigt sich mit der sehr undeutlichen und vor der Vereinigung durch den grossen Eindruck der Zwischenräume überlagerten 3. und dem Ende der 4. Rippe. Die Flügeldecken besitzen kräftige Eindrücke innerhalb der Schultern, hinter dem Schildchen zwischen Naht und 1. Rippe, hinter den Schultern innerhalb des Seitenrandes, vor der Spitze zwischen 2. Rippe und Naht und vor der Vereinigung der 2. bis 4. Rippe. Hauptpunktierung der Flügeldecken grob bis sehr grob, mässig dicht, es bilden zwei bis vier Punkte eine unregelmässige Querreihe, zwischen je zwei Punkten hat meist nur ein Punkt Platz. Grundpunktierung wenig fein und ziemlich dicht. Flügeldecken im Basaldrittel ziemlich stark gewölbt, von da zur Spitze fast geradlinig und erst unmittelbar vor ihr wieder etwas schräger abfallend. Schienen ziemlich schlank, gegen die Mitte leicht eingebogen, Tarsen ziemlich schlank, das 2. bis 4. Tarsenglied etwas höher als lang. Das Klauenglied etwa von der Mitte ab breiter als die vorhergehenden Glieder. Länge 13,5, Schulterbreite 4,2, Fühlerlänge 8,5 mm.

Durch die zur Spitze ziemlich stark verbreiterten, für diese Untergattung verhältnismässig langen Fühlerlamellen sehr ausgezeichnet.

Es liegt mir noch ein 2. vielleicht zu dieser Art gehöriges Stück (Borneo Samml. Halsschild, Universitetets Zoologiske Museum, Kopenhagen) vor, bei dem die Fühler fast vollständig fehlen, der Halsschild viel schwächer gewölbt und fein und dicht punktiert ist, die Hauptpunktierung der Flügeldecken weniger dicht ist und die Halsschildvorderecken viel schwächer vorgezogen sind. Da das 4. bis 11. Fühlerglied fehlen, kann es sich jedoch auch um eine *Callirrhipis* s. str. aus der Verwandtschaft der *C. glabra* Pic handeln.

283300—4

# NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), XVII[1]

By CHARLES P. ALEXANDER

*Of Amherst, Massachusetts*

THREE PLATES

The present report on the rich tipulid collections made in the Philippines by my friends Messrs. Charles F. Clagg, Richard C. McGregor, and Francisco Rivera is devoted entirely to species from Luzon and Mindanao. The genera *Trichoneura* and *Troglophila* are added to the record for the Islands. A revised key to the species of *Trentepohlia* is supplied. Especially noteworthy is the large number of additions made to the list of the small and obscure species of the eriopterine genera *Gonomyia* and *Erioptera*. My continued gratitude to the above-mentioned entomologists is heartily extended for the privilege of retaining the types of the novelties in my own collection.

## LIMONIINÆ

### LIMONIINI

**LIMONIA (LIMONIA) LANGUIDA** sp. nov. Plate 1, fig. 1; Plate 2, fig. 25.

Allied to *davaoensis;* mesonotal præscutum yellow, with three brown stripes on the posterior portion of disk; pleura with a conspicuous black longitudinal stripe; halteres brownish black; femora brown, the tarsi and distal ends of tibiæ paling to obscure yellow; male hypopygium with the basistyle bearing two very unequal lobes on mesal face; a single complex dististyle; gonapophyses elongate, the outer margin strongly corrugated.

*Male.*—Length, about 3 millimeters; wing, 3.8.

Rostrum and palpi black. Antennæ black throughout; flagellar segments elongate-oval, with short, stout apical pedicels; verticils relatively stout and inconspicuous, shorter than the segments; terminal segment elongate, exceeding one and one-half times the length of the penultimate. Head dark gray.

Mesonotal præscutum chiefly light yellow, with three more or less distinct brown stripes on the posterior two-thirds, the

[1] Contribution from the entomological laboratory, Massachusetts State College.

cephalic third without markings; lateral stripes narrow; lateral margin of sclerite weakly darkened; lobes of scutum darkened; remainder of mesonotum chiefly obscure yellow. Pleura pale yellow, with a narrow but conspicuous longitudinal black stripe, broadest in front, narrowed behind, passing beneath the halteres. Halteres brownish black, the basal fourth of stem light yellow. Legs with coxæ and trochanters very pale yellow, only the fore coxæ a little darker; femora and tibiæ brown, the latter toward their tips, together with tarsi, paling to obscure yellow; claws slender, with a relatively small basal tooth and an elongate seta. Wings (Plate 1, fig. 1) grayish subhyaline, the prearcular and costal regions very weakly infumed; stigma short-oval, darker brown; veins dark brown. Macrotrichia of veins relatively long and conspicuous. Venation: $Sc_1$ ending about opposite two-fifths the length of Rs, $Sc_2$ not far from its tip; m-cu at fork of M.

Abdomen brownish black, including the hypopygium. Male hypopygium (Plate 2, fig. 25) with the caudal margin of tergite, *9t*, broadly and convexly rounded. Basistyle, *b*, with a very large flattened ventromesal lobe, in addition to a much smaller, dusky, clavate lobule. Only a single dististyle, *d*, is evident in the material on hand, the body divided into two fingerlike lobes that are provided with long coarse setæ, those of the slenderer lobe slightly longer; rostral prolongation elongate, flattened, without evident rostral spines. Gonapophyses, *g*, elongate, the outer margin conspicuously corrugated.

LUZON, Tayabas Province, Lucban, January 26, 1931 (*Rivera*); holotype, male.

The general structure of the basistyle, dististyle, and gonapophyses of the male hypopygium shows the present species to be allied to a small group of Philippine species centering about *Limonia* (*Limonia*) *davaoensis* Alexander, such as this latter species and *L.* (*L.*) *bilobulifera* Alexander. It differs very evidently in the structure of the male hypopygium, being most similar to *bilobulifera*, but still quite distinct in the details of both venation and hypopygium.

**LIMONIA (LIMONIA) ERRATICA sp. nov.** Plate 1, fig. 2; Plate 2, fig. 26.

General coloration dark brown, the pleura obscure yellow; anterior vertex silvery; legs black, the tarsi and tips of tibiæ paling to yellow; wings with a strong brown suffusion; Sc long, $Sc_1$ ending about opposite four-fifths the length of Rs; free tip of $Sc_2$ lying distad of $R_2$, $R_{1+2}$ projecting as a long spur beyond

either of these elements; m-cu close to fork of M; abdominal tergites brownish black, the sternites yellowish; male hypopygium with the ventral dististyle fleshy, much larger than the basistyle, the rostral prolongation with two spines; caudal border of tergite weakly bilobed.

*Male.*—Length, 5.5 to 6.3 millimeters; wing, 6 to 7.

Rostrum and palpi black. Antennæ black throughout; flagellar segments long-oval to subcylindrical, the verticils relatively short, less than the segments in length; terminal segment elongate, at apex narrowed into a button. Head blackish, the broad anterior vertex silvery.

Mesonotum and pleurotergite uniformly dark brown. Pleura obscure yellow, the propleura blackened. Halteres brownish black, the base of stem narrowly pale. Legs with the fore coxæ blackened, the remaining coxæ and all trochanters obscure yellow; femora black, slightly brightened at bases; tibiæ brown, their tips and all tarsi paling to obscure yellow; claws relatively small, nearly straight, each with two slender setiform spines at base, the outer one larger. Wings (Plate 1, fig. 2) with a strong brown tinge, the costal region and cell $Cu_1$ slightly darker; stigma oval, darker brown; veins dark brown. Costal fringe dense but rather short. Venation: Sc long, $Sc_1$ ending about opposite four-fifths the length of the long Rs, the latter narrowly angulated at origin; free tip of $Sc_2$ and $R_2$ both pale, opposite one another, or the latter lying proximad of the former, $R^{1+2}$ jutting some distance beyond these veins as a spur, provided with trichia; m-cu close to fork of M.

Abdominal tergites and hypopygium brownish black; sternites obscure yellow. Male hypopygium (Plate 2, fig. 26) with the tergite, *9t*, strongly narrowed apically, the caudal margin gently emarginate, each lobe thus formed with a close group of about eight long coarse setæ. Basistyle, *b*, short and stout, the ventromesal lobe occupying almost the whole mesal face. Ventral dististyle, *vd*, large and fleshy, the rostral prolongation slender, with two spines that are placed close together, these subequal in length to the prolongation itself. Gonapophyses, *g*, very broad, the mesal-apical lobe relatively short, its margin irregularly and weakly roughened but scarcely serrulate.

LUZON, Tayabas Province, Lucban (*Rivera*); holotype, male, January 25, 1931; paratypes, 3 males, January 24–26, 1931; MINDANAO, Cotobato Province, Mount Matutum, April 29, 1932 (*Rivera*); paratypes, 2 males.

In the characters listed in the above diagnosis, *Limonia* (*Limonia*) *erratica* differs widely from the other Philippine species of the subgenus, with the single exception of *L.* (*L.*) *melanoptera* sp. nov. The male hypopygium of both of these species is very similar to that of *Dicranomyia* but the unusually long Sc requires the assignment of the flies to *Limonia.* In the projection of vein $R_{1+2}$ as a spur beyond the level of either $R_2$ or the free tip of $Sc_2$ the present fly is distinct from the other Philippine species of the subgenus.

**LIMONIA (LIMONIA) MELANOPTERA sp. nov. Plate 1, fig. 3; Plate 2, fig. 27.**

General coloration of thorax dark fulvous or brownish yellow; antennæ black, the verticils much shorter than the segments; legs brownish black; wings strongly suffused with blackish, cells C and Sc darker; Sc long, $Sc_1$ ending just before the fork of Rs; $R_{1+2}$ not projecting beyond level of $R_2$; abdomen black; male hypopygium with caudal margin of tergite convexly rounded.

*Male.*—Length, about 5 to 5.5 millimeters; wing, 6 to 6.8.

Rostrum and palpi black. Antennæ black throughout, relatively elongate (male); flagellar segments long-oval to subcylindrical, with very short apical necks; segments clothed with a dense abundant erect pubescence and scattered verticils that are only about one-third the length of the segments. Head black; anterior vertex reduced to a capillary line or virtually lacking by approximation of eyes.

Pronotum almost hidden beneath the cephalic margin of præscutum, black. Mesonotal præscutum dark fulvous or brownish yellow, the scutal lobes weakly darkened, especially along their mesal and cephalic edges; scutellum more infuscated, the posterior edge pale. Pleura brownish yellow, polished. Halteres dusky. Legs with coxæ and trochanters obscure yellow; femora brownish black, the narrow bases obscure yellow; tibiæ and tarsi passing into black. Wings (Plate 1, fig. 3) strongly suffused with blackish, cells C and Sc, with the oval stigma, darker brown; veins brownish black. Venation: Sc long, $Sc_1$ ending just before fork of Rs, $Sc_2$ at its tip; m-cu at or close to fork of M; cell 1st $M_2$ relatively small.

Abdomen, including hypopygium, black. Male hypopygium (Plate 2, fig. 27) with the caudal margin of the tergite, *9t,* evenly and strongly convex, not bilobed as in *erratica.* Basistyle, *b,* with two separate ventromesal lobes, the more apical one smaller. Ventral dististyle, *vd,* large and fleshy, the rostral prolongation with two spines of moderate length.

LUZON, Mountain Province, Benguet, Clark's Place, Camp 66, altitude 7,000 feet, October 6, 1931 (*Rivera*); holotype, male, paratypes, 2 males; Bontoc, Mount Data, altitude 6,000 feet, October 9, 1931 (*Rivera*); paratype, male.

The only regional species of the subgenus that has a somewhat similarly darkened wing pattern and bispinous rostral prolongation of the male hypopygium is *Limonia* (*Limonia*) *erratica* sp. nov. The present fly differs in numerous respects, as the more elongate antennæ, with unusually short verticils; dark brownish yellow thorax; blackened tibiæ and tarsi; and in the details of venation and structure of the male hypopygium, as discussed above.

**LIMONIA (LIMONIA) PARVISPICULATA** sp. nov. Plate 1, fig. 4; Plate 2, fig. 28.

General coloration of præscutum and scutal lobes brownish black, pleura obscure yellow; antennæ black throughout; legs dark brown, the tarsi paler; wings with a brownish tinge; male hypopygium with the ventral dististyle an oval structure, the outer margin narrowly blackened, the rostral prolongation represented only by a small peglike spine that is placed beyond midlength of the style.

*Male*.—Length, about 3.5 millimeters; wing, 4.2.

Rostrum and palpi black. Antennæ black throughout; flagellar segments oval, with short stout apical pedicels; longest verticils a trifle shorter than the segments; terminal segment longer than the penultimate, strongly narrowed outwardly. Head blackish, sparsely pruinose; anterior vertex and posterior orbits lighter gray.

Disk of mesonotal præscutum and the scutal lobes brownish black, the lateral portions of the præscutum broadly obscure yellow; posterior sclerites of mesonotum dark brown. Pleura obscure yellow. Halteres blackened, the base of stem restrictedly pale. Legs with the coxæ and trochanters obscure yellow; femora and tibiæ dark brown, the tarsi paling to light brown; claws relatively long and slender, with a long narrow basal spine and additional elongate setæ. Wings (Plate 1, fig. 4) with a brownish tinge, the oval stigma only a trifle darker; veins brown. Costal fringe relatively long and conspicuous; macrotrichia of veins basad of cord sparse or lacking, there being none on basal section of $Cu_1$ or on the anal veins, excepting a single apical one on each of the anals. Venation: Sc relatively short, $Sc_1$ ending about opposite two-fifths the length of Rs, $Sc_2$ at its tip; free tip of $Sc_2$ lying slightly proximad of

$R_2$, both elements pale and without macrotrichia; inner end of cell 1st $M_2$ arcuated; m-cu variable in position, in one wing of type at fork of M, in the opposite wing at near one-third the length of cell.

Abdominal tergites brownish black; basal sternites dusky in color, narrowly margined caudally with paler. Male hypopygium (Plate 2, fig. 28) with the tergite, *9t*, divided into two broad lobes by a median notch. Basistyle, *b*, relatively slender, the ventromesal lobe small, cushionlike, placed at cephalic end of style. Dorsal dististyle a pale ribbonlike blade that narrows very gradually to the acute tip. Ventral dististyle, *vd*, an oval structure, the outer margin narrowly blackened to apex; no rostral prolongation except a small peglike spine placed beyond midlength of style. Gonapophyses, *g*, with the mesal-apical lobe dusky, its apex unequally bidentate.

LUZON, Tayabas Province, Lucban, January 26, 1931 (*Rivera*); holotype, male.

The very peculiar structure of the ventral dististyle of the male hypopygium readily separates the present fly from the now numerous small regional species of *Limonia*. The structure of the dististyle and the wing venation remotely suggest *Limonia* (*Limonia*) *retrusa* Alexander (Luzon), which differs very evidently in the details of the styli and gonapophyses.

**LIMONIA (LIBNOTES) CIRCUMSCRIPTA** sp. nov. Plate 1, fig. 5; Plate 2, fig. 29.

Belongs to the *familiaris* group; mesonotum chiefly black, the sides of præscutum broadly deep reddish; knobs of halteres blackened; fore femora black, except the narrow yellow bases; wings whitish subhyaline, the prearcular region extensively and conspicuously pale yellow; costal region and a seam almost around wing margin brown; abdomen, including hypopygium, black; outer rostral spine of male hypopygium unusually long and slender.

*Male.*—Length, about 8 millimeters; wing, 9.3.

Rostrum and palpi black. Antennæ with scape and pedicel black; flagellum broken. Head dull grayish black; anterior vertex reduced to a linear strip.

Pronotum black. Mesonotal præscutum deep reddish, with a single broad black median stripe; remainder of mesonotum black. Pleura chiefly brownish yellow, the dorsal sclerites somewhat darker. Halteres yellow, the knobs blackened. Legs with the coxæ dark reddish brown; trochanters obscure yellow; femora yellow basally, the tips black, on forelegs only the very

narrow bases brightened, on middle and hind legs the coloration of the extensive central portion more brownish, the tips narrowly blackened; tibiæ brownish black; tarsi passing into black. Wings (Plate 1, fig. 5) whitish subhyaline, the prearcular region abruptly and conspicuously pale yellow; cells C and Sc dark brown, about as intense in color as the subcircular stigma; the entire border of wing, excepting the axilla, is broadly and distinctly clouded with brown, broadest at the apex; seams at origin of Rs, along cord and outer end of cell 1st $M_2$ extremely restricted to almost lacking; cell $Cu_1$ (between branches of Cu) darkened; veins brown, darker in the clouded areas. Venation: $Sc_1$ ending beyond the level of the shortened r-m, $Sc_2$ some distance from its tip but very ill-defined; Rs and basal section of $R_{4+5}$ almost in feebly oblique alignment; m-cu about its own length beyond the fork of M; anal veins at base feebly divergent.

Abdominal tergites black, the sternites almost as deeply colored; hypopygium black. Male hypopygium (Plate 2, fig. 29) with the tergite, *9t*, deeply notched medially, the setæ marginal. Ventral dististyle, *vd*, large and fleshy, the rostral spines unequal in length and size, the outer one unusually long and straight; rostral prolongation beyond the last spine pendant. Dorsal dististyle stout on more than basal half, strongly curved, the outer portion very slender and acute.

LUZON, Mountain Province, Bontoc, Mount Data, altitude 6,000 feet, October 9, 1931 (*Rivera*); holotype, male.

By Edwards's key to the species of *Libnotes* [2] the present fly runs to couplet 59, disagreeing with the included species and all others in the key and described since its publication by the peculiar wing pattern, as described. The following Philippine species, *Limonia* (*Libnotes*) *melancholica* Alexander, *L.* (*L.*) *neofamiliaris* Alexander, *L.* (*L.*) *subfamiliaris* Alexander, and *L.* (*L.*) *unistriolata* Alexander, all have a somewhat similar type of male hypopygium, but all differ in the uniform nature of the wing pattern, with no prearcular brightening.

**LIMONIA (LIBNOTES) RARISSIMA sp. nov.** Plate 1, fig. 6; Plate 2, fig. 30.

General coloration yellow, the præscutum with a narrow median brownish black stripe; scutellum and mediotergite blackened; femora black, the narrow bases and tips yellow, the amount subequal at the two ends; tibiæ and tarsi brownish

[2] Journ. Fed. Malay States Mus. 14 (1928) 74–80.

yellow; wings pale yellow, the cord and outer end of cell 1st $M_2$ conspicuously seamed with brown; $Sc_2$ elongate; m-cu long; male hypopygium with the ventral dististyle large and fleshy; rostral prolongation with two unequal spines, the outermost stouter, curved toward tip.

*Male.*—Length, about 7.5 to 8 millimeters; wing, 8 to 8.5.

*Female.*—Length, about 8 millimeters; wing, 8.2.

Rostrum and palpi black, the former one-third the length of the remainder of head. Antennæ (male) greenish black, in life probably clear green; flagellar segments subglobular to short-oval, with short necks; in female, flagellar segments darker in color and more elongate-oval. Head blackish; anterior vertex reduced to a linear strip.

Pronotum black. Mesonotal præscutum obscure yellow, with a single brownish black median stripe; scutal lobes with centers similarly darkened; scutellum black, with indications of a capillary pale median vitta; mediotergite blackened, the cephalic lateral portions more yellowish. Pleura yellow or greenish yellow, in male with restricted darkened areas on anepisternum and before root of halteres. Halteres pale greenish, the knobs more yellowish. Legs with the coxæ and trochanters yellow; only a single leg (fore) remains; femora black, the tips and bases narrowly but conspicuously yellow, the amount subequal on both ends; tibiæ and tarsi brownish yellow, the terminal tarsal segments darkened. Wings (Plate 1, fig. 6) pale yellow, the prearcular region clearer yellow; cells C and Sc light brown; a heavy darker brown seamed pattern, as follows: Arcular region, origin of Rs, cord and outer end of cell 1st $M_2$, stigma, and a narrow darkened apical and posterior border; veins brownnish black, the prearcular veins yellow. Venation: $Sc_1$ ending some distance beyond fork of Rs, $Sc_2$ far before its tip; Rs strongly arcuated; free tip of $Sc_2$ just before level of $R_2$; cell 1st $M_2$ long, m longer and more arcuated than the basal section of $M_3$; m-cu before fork of M, subequal to or slightly longer than the distal section of $Cu_1$; anal veins at bases parallel or slightly divergent.

Abdomen pale yellow. Male hypopygium (Plate 2, fig. 30) with the tergite, *9t*, deeply notched, the lateral lobes with conspicuous marginal setæ, the outermost larger and coarser. Ventral dististyle, *vd*, large and fleshy; rostrum slender, with two unequal spines, the outer stouter and bent before tip. Gonapo-

physyses and basistyles damaged. Ovipositor with cerci slender, gently upcurved to the simple tips.

LUZON, Mountain Province, Benguet, Haight's Place, Pauai, altitude 8,000 feet (*Clagg and Rivera*); holotype, male, October 2, 1931; allotype, female, October 6, 1931; paratype, sex?; Bontoc, Mount Data, altitude 6,000 feet, October 8, 1931 (*Clagg and Rivera*); paratype, a teneral male.

By Edwards's key to the species of the subgenus[3] the present fly runs to couplet 58, disagreeing with both included species in the conspicuous wing pattern. Superficially it is much like *Limonia* (*Libnotes*) *perrara* Alexander, likewise from Pauai, which belongs to an entirely different group of the subgenus.

### LIMONIA (DICRANOMYIA) SORDIDA BREVICULA subsp. nov.

Closely similar to typical *sordida* (Brunetti), differing especially in the much shorter rostral spines of the male hypopygium. These spines are about one-third the diameter of the rostrum at point of their insertion and are shorter than the longest setæ at apex of the prolongation. In *sordida* the spines are about as long as one-half the diameter of the prolongation and distinctly longer than the setæ.

LUZON, Mountain Province, Benguet, Haight's Place, Pauai, altitude 8,000 feet, October 6, 1931 (*Clagg and Rivera*); holotype, male, allotype, female, paratypes, males and females, October 5 and 6, 1931.

### HELIUS (RHAMPHOLIMNOBIA) BREVINASUS sp. nov. Plate 1, fig. 7.

General coloration dark brown; rostrum relatively short, black throughout; knobs of halteres infuscated; wings whitish subhyaline, with a conspicuous brown pattern that is not reticulate; inner end of cell 1st $M_2$ strongly arcuated and pointed; abdominal sternites ringed caudally with silvery.

*Female.*—Length, excluding rostrum, about 6.5 millimeters; wing, 5; rostrum, 0.7.

Rostrum much shorter than in the subgenotype, *reticularis*, black throughout; palpi brown. Antennæ brownish black, the scape and pedicel somewhat more intense. Anterior vertex silvery gray, posterior vertex blackish.

Cervical region and pronotum blackish. Mesonotum chiefly dark brown, the præscutum vaguely more yellowish sublaterally

[3] Loc. cit.

and in the humeral region; median region of scutum somewhat brightened. Pleura brownish black, with indications of a narrow paler stripe on dorsal sternopleurite; pleurotergite somewhat paler, more obscure brownish yellow. Halteres pale, the knobs infuscated. Legs with the coxæ and trochanters blackened; remainder of legs broken. Wings (Plate 1, fig. 7) whitish subhyaline, with cells C and Sc more yellowish; a relatively restricted but conspicuous dark brown pattern that is confined to the vicinity of the veins, as follows: Arculus; origin of Rs; along cord and m; stigmal area, this latter confluent with a cloud at fork of Rs; darkened clouds at end of vein $R_3$ and near wing apex in outer end of cell $R_3$; paler marginal clouds at ends of veins $Cu_1$ and 2d A; a very narrow and indistinct brown seaming from wing tip back along margin to vein $M_4$; axillary region clouded; veins dark brown. Venation: r-m nearly its own length before fork of Rs; branches of Rs strongly divergent; inner end of cell 1st $M_2$ strongly arcuated and pointed; m-cu before fork of M.

Abdominal tergites blackened; a silvery area on intermediate pleural rings opposite posterior half of tergites; sternites brown, darker laterally, the posterior borders narrowly and conspicuously silvery. Ovipositor with the elongate valves yellowish horn color.

MINDANAO, Davao district, Tagum, Madaum River, March 27, 1931, at trap lantern (*Clagg*); holotype, female.

*Helius* (*Rhampholimnobia*) *brevinasus* is readily told from *H.* (*R.*) *reticularis* (Alexander) by the short rostrum and non-reticulated wing pattern.

### LECHRIINI

**TRICHONEURA (XIPHOLIMNOBIA) BONTOCENSIS sp. nov. Plate 1, fig. 8; Plate 2, fig. 31.**

General coloration light to dark brown, the pleura pruinose; antennæ and legs black; wings suffused with brownish; Rs about one-fifth longer than R; male hypopygium with the tergite profoundly split medially; longest dististyle biramous, one arm terminating in a powerful fasciculate seta, the other in numerous small spines.

*Male.*—Length, about 2.5 to 3 millimeters; wing, 3 to 3.8.

Rostrum and palpi black. Antennæ black; flagellar segments elongate oval. Head dark gray.

Mesonotum dark brown, the pleura heavily pruinose with gray. Halteres dusky, the base of stem narrowly brightened.

Legs with the coxæ and trochanters brownish testaceous; remainder of legs brownish black to black. Wings (Plate 1, fig. 8) suffused with brownish; stigmal region not or scarcely darker; veins darker brown. Venation: $Sc_1$ ending about opposite four-fifths the length of Rs, the latter only about one-fifth longer than R; m-cu shortly beyond midlength of cell 1st $M_2$.

Abdomen brownish black; hypopygium obscure yellow. Male hypopygium (Plate 2, fig. 31) with the tergite, *9t,* having a deep median notch, the truncated lobes without setæ. Dististyle, *d,* terminal including three distinct styli or branches; a short fingerlike lobe that is densely set with stout setæ and more delicate setulæ throughout its length; a slightly more elongate and more slender fingerlike lobe that bears two long setæ at and just before tip, the latter produced beyond the point of insertion of outer seta as a slender point; largest style a powerful arm that is two-branched at apex, one arm smooth, its truncated end further produced into a powerful curved fasciculate seta, the second arm more slender and slightly more elongate, set with numerous spinous points.

LUZON, Mountain Province, Bontoc, Kabunagan, October 11, 1931 (*Rivera*); holotype, male: Tayabas Province, Candelaria, near a small stream, June 25, 1930 (*McGregor and Rivera*); paratypes, 3 males.

The paratypes are much paler than the type, as described, but from the venation and structure of the male hypopygium, are conspecific.

The two known genera of the Lechriini may be separated as follows:

1. Cell 1st $M_2$ elongate, the basal section of $M_{1+2}$ subequal in length to Rs; r-m placed about its own length before fork of Rs........ *Lechria* Skuse.
   Cell 1st $M_2$ of normal size, the basal section of $M_{1+2}$ less than one-third the length of the long Rs; r-m normally placed, on $R_{4+5}$ shortly beyond the origin of the latter .................................................. *Trichoneura* Loew.

Both of the known genera have now been discovered in the Philippines. The two described species of *Lechria* in the Islands have been figured by the writer in an earlier part of this series of papers.[4]

The genus *Trichoneura* is of great interest in that it is one of two genera of Tipulidæ that was first described as a fossil genus and was later found to have living relatives in various

[4] Philip. Journ. Sci. 40 (1929) 261–262, pl. 1, figs. 11, 12.

parts of the Old World. I would recognize three subgenera, which may be separated by the following key:

1. Tibial spurs present (fossil; Baltic Amber, Lower Oligocene). *Trichoneura* Loew.
   Tibial spurs lacking ........ 2.
2. Vertex bearing a small pale lobe or cornicle; wings patterned (Ethiopian) ........ *Ceratolimnobia* Alexander.
   Vertex unarmed; wings unmarked (Ethiopian, Oriental). *Xipholimnobia* Alexander.

The first recent species of *Trichoneura* to be made known was described as *Lechria nepalensis* Brunetti, from Katmandu, Nepal.[5] No mention is made of the presence of tibial spurs and I believe the fly would pertain to *Xipholimnobia,* as above defined. The second *Xipholimnobia* to be described was *T.* (*X.*) *formosensis* (Alexander),[6] from Kanshirei, northern Formosa. The three species of the subgenus in eastern Asia may be separated by the following key:

1. Legs pale yellowish (Nepal) ........ *nepalensis* (Brunetti).
   Legs brown or black ........ 2.
2. Rs unusually long, being more than one-half longer than R alone (Formosa) ........ *formosensis* (Alexander).
   Rs shorter, being approximately one-fifth longer than R (Luzon). *bontocensis* sp. nov.

References to the various subgenera and discussion of the position of *Trichoneura* in the tribe Lechriini may be found in two of my papers, in addition to those above cited.[7]

### HEXATOMINI

**TROGLOPHILA COTABATOENSIS** sp. nov. Plate 1, fig. 9.

General coloration of thorax pale brown; antennæ with scape and pedicel light yellow, flagellum black; flagellar segments (male) elongate, weakly trinodose; legs brownish black; wings whitish subhyaline; Sc very long, $Sc_1$ ending nearly opposite the outer end of cell 1st $M_2$; $R_3$ running very close to $R_{1+2}$, cell $R_2$ at base narrow, vein $R_2$ short; cell 1st $M_2$ small, vein $M_{3+4}$ only about one-half as long as vein $M_4$ beyond it.

*Male.*—Length, about 3.8 millimeters; wing, 4.8; antenna, about 5.3.

[5] Brunetti, Rec. Indian Mus. 15 (1918) 317–318; Edwards, Rec. Indian Mus. 26 (1924) 301.

[6] Philip. Journ. Sci. 22 (1923) 473–474.

[7] Proc. Linn. Soc. New South Wales 52 (1927) 54–55; Crane-flies of the Baltic Amber (Diptera), Bernstein-Forschungen (Amber Studies) 2 (1931) 54–57, figs. 62–67.

Rostrum yellow; palpi brown. Antennæ with scape and pedicel light yellow, flagellum black; in male, antennæ exceeding the wing in length, as shown by the measurements; flagellar segments elongate-cylindrical to feebly trinodose, with long outspreading setæ at the nodes, these setæ subequal in length to the segments. Eyes very large, reducing the anterior vertex to a linear strip, the inner margin opposite the antennal fossæ conspicuously emarginate. Front light yellow; vertex dark gray.

Thorax uniformly pale brown, the sternopleurite clearer yellow. Halteres chiefly pale. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs brownish black, the femoral bases restrictedly obscure yellow. Wings (Plate 1, fig. 9) whitish subhyaline, the veins and very long macrotrichia dark brown. Venation: Sc of unusual length for a member of this genus, $Sc_1$ extending to nearly opposite the outer end of cell 1st $M_2$, $Sc_2$ a short distance from its tip; Rs arcuated, much shorter than the petiole of cell $R_3$; vein $R_3$ running very close to $R_{1+2}$, narrowing cell $R_2$ on its basal portion, vein $R_2$ being very short; cell 1st $M_2$ small, the veins issuing from it correspondingly lengthened; $M_{3+4}$ about one-half of $M_4$ alone; m longer than basal section of $M_3$ m-cu at fork of M; anterior arculus present.

Abdominal tergites and hypopygium dark brown; basal sternites yellow.

MINDANAO, Cotabato Province, Mount Matutum, April 29, 1932 (*Rivera*); holotype, male.

The nearest allies of the present fly are *Troglophila alticola* (Edwards), of Borneo, and *T. ritozanensis* Alexander, of Formosa. The present fly differs especially in the clear wings, with the venational details quite distinct, especially the long Sc, position of vein $R_3$, and the relative length of the veins issuing from cell 1st $M_2$.

### ERIOPTERINI

#### Genus TRENTEPOHLIA Bigot

*Trentepohlia* BIGOT, Ann. Soc. Ent. France III 2 (1854) 473.

The last general key to the Philippine species of *Trentepohlia* was one prepared by the writer [8] and included a total of fifteen species. Since the number of known species for the Islands has now doubled, it seems advisable to prepare a revised key to the species of this difficult genus.

[8] Philip. Journ. Sci. 43 (1930) 297–298.

*Key to the Philippine species of Trentepohlia Bigot.*

1. Wings with vein $R_3$ completely atrophied .......... 2.
Wings with vein $R_3$ preserved .......... 4.
2. Wings with cell 1st $M_2$ closed; three outer medial veins, $M_{1+2}$, $M_3$, and $M_4$ (not yet recorded from the Philippines; known from Borneo and Sumatra) .......... Subgenus *Plesiomongoma* Brunetti.
Wings with cell 1st $M_2$ open by the atrophy of m and the two distal sections of $M_3$; two outer medial veins, $M_{1+2}$ and $M_4$.
Subgenus *Anchimongoma* Brunetti 3.

Subgenus *Anchimongoma* Brunetti

3. Legs with the genua white, the color involving the femoral tips and tibial bases (Mindanao) .......... *apoicola* Alexander.
Legs with the femora and tibiæ uniformly darkened (Mindanao).
*beata* Alexander.
4. Wings with veins $Cu_1$ and 1st A fused for a distance back from the margin; cell 1st $M_2$ open or closed; if the latter, with three outer medial veins, $M_{1+2}$, $M_3$, and $M_4$ .......... 7.
Wings with veins $Cu_1$ and 1st A entirely separate at margin; cell 1st $M_2$ closed, two outer medial veins, $M_{1+2}$ and $M_4$.
Subgenus *Paramongoma* Brunetti 5.

Subgenus *Paramongoma* Brunetti

5. Tibiæ white (Mindanao) .......... *chionopoda* Alexander.
Tibiæ dark brown to black .......... 6.
6. Tips of femora narrowly but conspicuously whitened (Luzon).
*banahaoensis* Alexander.
Femora with tips uniformly darkened (Mindanao; Sunda Islands).
*pusilla* Edwards.
7. Wings with cell 1st $M_2$ closed; three outer medial veins, $M_{1+2}$, $M_3$, and $M_4$ .......... Subgenus *Mongoma* Westwood 8.
Wings with cell 1st $M_2$ open by the atrophy of m and the two distal sections of $M_3$; the outer medial veins, $M_{1+2}$ and $M_4$.
Subgenus *Trentepohlia* Bigot 26.

Subgenus *Mongoma* Westwood

8. Tips of femora abruptly and conspicuously white, the genua thus brightened .......... 9.
Femora either uniformly darkened, or uniformly pale, or pale with the tips narrowly blackened, the genua not at all brightened .......... 13.
9. Crossvein m-cu at or beyond midlength of cell 1st $M_2$ (Luzon).
*duyagi* Alexander.
Crossvein m-cu at or before the fork of M .......... 10.
10. $R_3$ strongly arcuated, subperpendicular at origin, cell $R_3$ thus widened at base (Luzon) .......... *saxatilis* Alexander.
$R_3$ not so strongly arcuated at origin, diverging gradually from $R_4$, cell $R_3$ not conspicuously widened at base .......... 11.

11. Mesonotal præscutum orange fulvous, narrowly darkened laterally (Mindanao) ........ *æquialba* Alexander.
    Mesonotal præscutum dark brown........ 12.
12. Wings with cells C and Sc undarkened, similar in coloration to remainder of wing; tibiæ uniformly pale (Luzon, Negros, Mindanao). *tenera* (Osten Sacken).
    Wings with cells C and Sc strongly infumed, darker than remainder of wing; tibiæ brown, the tips whitened (Mindanao). *teneroides* Alexander.
13. Mid-tibiæ with distal ends white, conspicuously feathered with long outspreading white setæ (Luzon, Leyte, Negros, Mindanao; Austromalayan) ........ *pennipes* (Osten Sacken).
    Mid-tibiæ normal, similar to other tibiæ........ 14.
14. At least the fore tibiæ either uniform in color throughout their length, pale or dark, or else pale with the tips black........ 15.
    All tibiæ with the tips whitened (Mindanao). *alboterminalis* Alexander.
15. At least the fore tibiæ pale, with the tips abruptly blackened........ 16.
    Tibiæ uniform in color, either dark or pale throughout........ 19.
16. Tibiæ of all legs approximately alike in color........ 17.
    Tips of fore tibiæ abruptly black, of the posterior tibiæ even more broadly snowy white (Luzon)........ *luzonensis* Edwards.
17. Tibiæ and basitarsi yellow, their extreme bases, as well as their tips, blackened; m-cu about one-half its length beyond the fork of M (Luzon)........ *ricardi* Alexander.
    Tibiæ and basitarsi not abruptly blackened at bases; m-cu at or before the fork of M........ 18.
18. Mesonotal præscutum polished black, the humeral region yellow; a dark area on anepisternum; abdominal tergites blackened (Mindanao). *æquinigra* Alexander.
    Mesonotal præscutum yellow, in cases restrictedly darkened at suture; pleura uniformly pale; abdominal tergites yellow, with a narrow, more or less interrupted dorsomedian dark stripe (Mindanao). *majuscula* Alexander.
19. General coloration of body, legs, and wings pale yellow (Luzon, Mindanao; northern Australia)........ *poliocephala* Alexander.
    General coloration of body, legs, and wings not pale yellow........ 20.
20. Mesonotal præscutum light yellow, with a median black line that broadens out behind (Luzon)........ *lætithorax* sp. nov.
    Mesonotal præscutum not colored as above........ 21.
21. Wings with m-cu at or beyond one-third the length of cell 1st $M_2$ (Mindanao) ........ *distalis* Alexander.
    Wings with m-cu at or before the fork of M........ 22.
22. Wings conspicuously patterned with brown, including broad seams on Rs and posterior cord; tarsi black (Mindanao).... *carbonipes* sp. nov.
    Wings immaculate, except for the more or less distinct stigmal darkening; tarsi paling to yellow or whitish........ 23.

23. Wings with cell $R_5$ longer than $M_3$; fusion between veins $R_5$ and $M_{1+2}$ relatively short, less than the second section of vein $M_{1+2}$ .......... 24.
Wings with cells $R_5$ and $M_3$ subequal; fusion of veins $R_5$ and $M_{1+2}$ long, exceeding twice the second section of $M_{1+2}$ .......... 25.
24. Mesonotum yellowish brown, somewhat darker medially; pleura obscure yellow, the dorsal portions dark brown; apical fusion of veins $Cu_1$ and 1st A conspicuous (Luzon) .......... *brevifusa* Alexander.
Mesonotum uniformly dark brown, the ventral pleurites paler; apical fusion of veins $Cu_1$ and 1st A very slight to almost lacking (Mindanao) .......... *persimilis* Alexander.
25. Mesonotal præscutum uniformly dark brown; cells C and Sc infumed, darker than the remainder of wing; cell $R_2$ at margin wide, exceeding one-half that of cell $R_3$ (Luzon) .......... *riverai* Alexander.
Mesonotal præscutum light fulvous yellow; cells C and Sc pale yellow, not infumed; cell $R_2$ at margin narrower, less than one-third cell $R_3$ (Mindanao) .......... *fulvinota* Alexander.

Subgenus *Trentepohlia* Bigot

26. Tips of femora abruptly whitened (Luzon) .......... *bakeri* Alexander.
Femora either uniformly pale in color, or pale with the tips narrowly blackened .......... 27.
27. Tips of femora and tibiæ conspicuously blackened; wings yellow, unmarked except for a narrow seam on vein $R_3$ (Luzon; Borneo, Java, Sumatra) .......... *mcgregori* Alexander.
Femora uniformly pale in color; wings not patterned as above .......... 28.
28. Wings almost immaculate, the costal border broadly suffused with yellow (Sibuyan) .......... *holoxantha* Alexander.
Wings with a conspicuous brown pattern .......... 29.
29. Abdomen entirely black (Luzon, Negros, Mindanao; Austromalayan). *pictipennis* Bezzi.
Abdomen with basal segments reddish, the terminal segments blackened. 30.
30. Wings heavily patterned with brown, the entire cephalic half infuscated, variegated only by four or five small white areas, the last one of which is at apex; wing base conspicuously dark brown (Mindanao). *lætipennis* Alexander.
Wings with entire costal border pale yellow, the tip abruptly darkened, without pale spot; no darkening at wing base (Luzon, Negros, Mindanao; Oriental, Austromalayan) .......... *trentepohlii* (Wiedemann).

The species of *Trentepohlia,* as they are now known from the Philippines, with references to their occurrence in the Islands, are as follows:

*Trentepohlia* (*Anchimongoma*) *apoicola* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 475–476, pl. 1, fig. 22.
*Trentepohlia* (*Anchimongoma*) *beata* Alexander; ALEXANDER, Philippines, XIV, Philip. Journ. Sci. **48** (1932) 46–47, pl. 1, fig. 22.
*Trentepohlia* (*Paramongoma*) *banahaoensis* Alexander; ALEXANDER, Philippines, VI, Philip. Journ. Sci. **41** (1930) 308–309, pl. 1, fig. 15.
*Trentepohlia* (*Paramongoma*) *chionopoda* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 469–470.

*Trentepohlia* (*Paramongoma*) *pusilla* Edwards; EDWARDS, Treubia **9** (1927) 356; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 470.

*Trentepohlia* (*Mongoma*) *æquialba* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** ( 1931) 470–471, pl. 1, fig. 18.

*Trentepohlia* (*Mongoma*) *æquinigra* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 472–473, pl. 1, fig. 19.

*Trentepohlia* (*Mongoma*) *alboterminalis* Alexander; ALEXANDER, Philippines, XIV, Philip. Journ. Sci. **48** (1932) 46, pl. 1, fig. 21.

*Trentepohlia* (*Mongoma*) *brevifusa* Alexander; ALEXANDER, Philippines, VII, Philip. Journ. Sci. **43** (1930) 300–301, pl. 1, fig. 18.

*Trentepohlia* (*Mongoma*) *carbonipes* sp. nov.; this report.

*Trentepohlia* (*Mongoma*) *distalis* Alexander; ALEXANDER, Philippines, XI, Philip. Journ. Sci. **46** (1931) 284–285, pl. 1, fig. 15.

*Trentepohlia* (*Mongoma*) *duyagi* Alexander; ALEXANDER, Philippines, VII, Philip. Journ. Sci. **43** (1930) 298–299, pl. 1, fig. 16.

*Trentepohlia* (*Mongoma*) *fulvinota* Alexander; ALEXANDER, Philippines, XVI, Philip. Journ. Sci. **49** (1932) 272–273, pl. 1, fig. 21.

*Trentepohlia* (*Mongoma*) *lætithorax* sp. nov.; this report.

*Trentepohlia* (*Mongoma*) *luzonensis* Edwards; EDWARDS, Notulæ Entomologicæ **6** (1926) 37–38; ALEXANDER, Philippines, V, Philip. Journ. Sci. **40** (1929) 265–266, pl. 1, fig. 13.

*Trentepohlia* (*Mongoma*) *majuscula* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 473–474, pl. 1, fig. 20.

*Trentepohlia* (*Mongoma*) *pennipes* (Osten Sacken); OSTEN SACKEN, Berlin. Ent. Zeitschr. **31** (1887) 204; BEZZI, Philip. Journ. Sci. § D **12** (1917) 115; EDWARDS, Notulæ Entomologicæ **6** (1926) 37; ALEXANDER, Philippines, IV, Philip. Journ. Sci. **33** (1927) 303.

*Trentepohlia* (*Mongoma*) *persimilis* Alexander; ALEXANDER, Philippines, XIV, Philip. Journ. Sci. **48** (1932) 45–46.

*Trentepohlia* (*Mongoma*) *poliocephala* Alexander; ALEXANDER, Philippines, V, VI, Philip. Journ. Sci. **40** (1929) 266–267, pl. 1, fig. 14; **41** (1930) 310–311.

*Trentepohlia* (*Mongoma*) *ricardi* Alexander; ALEXANDER, Philippines, VI, Philip. Journ. Sci. **41** (1930) 309–310, pl. 1, fig. 16.

*Trentepohlia* (*Mongoma*) *riverai* Alexander; ALEXANDER, Philippines, VII, Philip. Journ. Sci. **43** (1930) 299–300, pl. 1, fig. 17.

*Trentepohlia* (*Mongoma*) *saxatilis* Alexander; ALEXANDER, Philippines, V, Philip. Journ. Sci. **40** (1929) 267–269, pl. 1, fig. 15.

*Trentepohlia* (*Mongoma*) *tenera* (Osten Sacken); OSTEN SACKEN, Berlin. Ent. Zeitschr. **26** (1882) 89; ALEXANDER, Philippines, IV, Philip. Journ. Sci. **33** (1927) 302–303.

*Trentepohlia* (*Mongoma*) *teneroides* Alexander; ALEXANDER, Philippines, XVI, Philip. Journ. Sci. **49** (1932) 273–274, pl. 1, fig. 22.

*Trentepohlia* (*Trentepohlia*) *bakeri* Alexander; ALEXANDER, Philippines, IV, V, Philip. Journ. Sci. **33** (1927) 304–305, pl. 2, fig. 15; **40** (1929) 269.

*Trentepohlia* (*Trentepohlia*) *holoxantha* Alexander; ALEXANDER, Philippines, V, Philip. Journ. Sci. **40** (1929) 269–270, pl. 1, fig. 16.

*Trentepohlia* (*Trentepohlia*) *lætipennis* Alexander; ALEXANDER, Philippines, XII, Philip. Journ. Sci. **46** (1931) 474–475, pl. 1, fig. 21.

*Trentepohlia* (*Trentepohlia*) *mcgregori* Alexander; ALEXANDER, Philippines, IV, Philip. Journ. Sci. 33 (1927) 303–304, pl. 2, fig. 12.

*Trentepohlia* (*Trentepohlia*) *pictipennis* Bezzi; BEZZI, Philip. Journ. Sci. § D 12 (1917) 115; EDWARDS, Notulæ Entomologicæ 6 (1926) 37.

*Trentepohlia* (*Trentepohlia*) *trentepohlii* (Wiedemann); WIEDEMANN, Aussereur. zweifl. Ins. 1 (1828) 551; ALEXANDER, Philippines, IV, Philip. Journ. Sci. 22 (1927) 303.

The roman numerals with the various Alexander references given above refer to the various parts of the Philippine series of papers.

**TRENTEPOHLIA (MONGOMA) CARBONIPES** sp. nov. Plate 1, fig. 10.

Mesonotal præscutum light fulvous brown, the mediotergite and pleura abruptly dark brown; legs black, the femoral bases restrictedly yellow; wings tinged with grayish brown, cells C and Sc more brownish yellow; stigma and conspicuous seams on certain veins brown; wing apex slightly darkened; less distinct brown seams on outer end of cell 1st $M_2$; Rs short, subequal to basal section of $R_5$ and the cephalic face of cell 1st $M_2$.

*Female.*—Length, about 8 millimeters; wing, 8.3.

Rostrum testaceous; palpi dark brown. Antennæ brownish black throughout; flagellar segments cylindrical, with very short verticils. Head dark.

Pronotum and mesonotal præscutum light fulvous brown; scutal lobes dark brown; scutellum obscure yellow, the center of disk at base dark brown; mediotergite dark brown. Pleura uniformly dark brown, only the meral region paler. Halteres infuscated, the base of stem restrictedly yellow. Legs with the coxæ brownish; trochanters yellow; remainder of legs black, only with the femoral bases very restrictedly yellowish; legs without specially modified spines or setæ. Wings (Plate 1, fig. 10) tinged with grayish brown; cells C and Sc, together with the abbreviated prearcular region, more brownish yellow; stigma triangular, dark brown; certain veins with conspicuous brown seams, as follows: Arcular and axillary regions, Rs and posterior cord, radial veins beyond stigma; wing apex darkened; less distinct brown seams on outer end of cell 1st $M_2$. Venation: Rs short, subequal to basal section of $R_5$ and the cephalic face of cell 1st $M_2$ ($R_5 + M_{1+2}$); $R_2$ just before base of cell $R_3$; inner ends of cells $R_5$ and $M_3$ about in transverse alignment; m-cu at fork of M; apical fusion of veins $Cu_1$ and 1st A slight.

Abdominal segments indistinctly bicolorous, dark brown, the bases of the segments slightly paler.

MINDANAO, Cotabato Province, Mount Matutum, April 12, 1932 (*Rivera*); holotype, female.

*Trentepohlia* (*Mongoma*) *carbonipes* is abundantly different from all other Philippine species of the subgenus in the black legs and conspicuously patterned wings. By Edwards's synopsis of the Oriental and Australasian species of *Mongoma*[9] the fly runs to *T.* (*M.*) *sarawakensis* Edwards (Borneo), a very different fly that has the femoral tips pale and the thorax uniformly brownish ocherous.

**TRENTEPOHLIA (MONGOMA) LÆTITHORAX sp. nov.** Plate 1, fig. 11.

Mesonotal præscutum light yellow, with a conspicuous black median line that widens behind; posterior portion of mediotergite obscure yellow; dorsal pleurites black, the sternopleurite yellow; legs light brown; wings grayish subhyaline, the outer costal region and stigma brown; cell $R_2$ at wing margin narrower than at base; proximal end of cell $M_3$ lying proximad of cell $R_5$; abdomen black.

*Male.*—Length, about 5.5 millimeters; wing, 6.

*Female.*—Length, about 6 millimeters; wing, 6.

Rostrum, palpi, and antennæ black; flagellar segments of latter long-oval, with short verticils. Head dark gray.

Mesonotal præscutum clear yellow, with a very conspicuous median black line, narrowest in front, behind the level of the pseudosutural foveæ widened out, crossing the suture and including all of the scutum except the cephalic-lateral portions of the scutal lobes, which are light yellow; region of pseudosutural foveæ and extreme lateral margin of præscutum narrowly infuscated; scutellum black; mediotergite with slightly more than the cephalic half black, the posterior portion obscure yellow, divided by a capillary black median vitta. Pleura with the dorsal sclerites blackened, the sternopleurite yellow. Halteres faintly tinged with dusky, especially the knobs. Legs with the coxæ testaceous yellow, the fore coxæ and bases of mid-coxæ slightly more infumed; trochanters yellow; remainder of legs almost uniformly light brown; fore femora with a series of from six to eight strong bristles near base. Wings (Plate 1, fig. 11) grayish subhyaline, the outer costal region and stigma brown; wing apex narrowly and insensibly infumed; veins dark brown. Venation: $R_3$ diverging strongly from $R_4$, cell $R_2$ at margin narrower than at proximal end; proximal end of cell $M_3$ lying basad of that of

[9] Journ. Fed. Malay States Mus. 14 (1928) 110–111.

cell $R_5$; apical fusion of veins $Cu_1$ and 1st A slight; cell 2d A wide.

Abdomen, including hypopygium, black.

LUZON, Tayabas Province, Lucban (*Rivera*); holotype, male, January 25, 1931; allotype, female, January 22, 1931; paratype, female, January 26, 1931.

**GONOMYIA (PTILOSTENA) COTABATOENSIS sp. nov. Plate 1, fig. 12; Plate 2, fig. 32.**

Thoracic dorsum chiefly dark brown; basal two segments of antennæ more or less yellow; legs yellow, the tips of tibiæ and outer tarsal segments darkened; wings tinged with yellow, unmarked except for the small brown stigma; veins $R_{1+2}$ and $R_3$ contiguous at margin; male hypopygium with the inner dististyle terminating in two powerful blackened spikelike points, directed laterad at a right angle to apex of lobe; ædeagus entirely pale, the slightly expanded outer end with abundant black setulæ.

*Male.*—Length, about 4.5 millimeters; wing, 4.2.

*Female.*—Length, about 5.5 millimeters; wing, 4.8.

Rostrum and palpi black. Antennæ with scape dark beneath, lined with yellow above; pedicel chiefly light yellow; flagellum brownish black throughout; flagellar segments fusiform, with long conspicuous verticils. Head obscure brownish yellow, the center of vertex dusky.

Pronotum and anterior lateral pretergites light yellow. Mesonotal præscutum chiefly dark brown, with a median plumbeous gray stripe, the lateral borders pale yellow; posterior sclerites of notum chiefly dark brown, the posterior border of scutellum broadly obscure yellow. Pleura almost uniformly pale brown, the dorsal sclerites darker. Halteres dusky. Legs with the coxæ and trochanters yellowish testaceous; remainder of legs light yellow, the tips of the tibiæ very narrowly but conspicuously brownish black; tarsi blackened. Wings (Plate 1, fig. 12) tinged with yellow, the costal region clear light yellow; stigma small, subcircular, dark brown; veins pale brown, the extreme base of Rs and the cord darker brown; veins C and Sc more yellowish. Venation: $Sc_1$ ending about opposite one-third the length of the strongly arcuated Rs; distal end of $R_1$ running very close to costa, at tip confluent with $R_3$; m-cu about one and one-half times its length before the fork of M.

Abdominal tergites weakly bicolorous, the basal portions on sides obscure yellow, the caudal portions dark brown, more or less distinctly divided medially by a pale line; sternites clear light yellow. Male hypopygium (Plate 2, fig. 32) with the inner dis-

tistyle, *id,* blackened at tip and produced laterad into two strong spikelike spines, with a smaller erect black spine at apex. Outer style, *od,* a long pale sinuous rod. Branches of intermediate style blackened along margin. There is evidently still another branch or style, partly broken in the type, here represented by a broad, pale flattened blade. Ædeagus, *a,* slender at base, a little expanded toward apex, entirely pale; outer expanded portion set with abundant microscopic setulæ.

MINDANAO, Cotabato Province, Makar, Nupol, March 30, 1932 (*Rivera*); holotype, male; Covell, Buayan, March 25, 1932 (*Rivera*); allotype, female; Mount Matutum, April 9, 1932 (*Rivera*); paratype, male.

*Gonomyia* (*Ptilostena*) *cotabatoensis* is very different from the two species of the subgenus hitherto reported from the Philippines (*metatarsata* de Meijere and *punctipennis* Edwards), differing from the former in the uniformly pale yellow femora, and from the latter in the unspotted wings and very different structure of the male hypopygium. It is also quite distinct from the far more numerous species of the subgenus now known from Japan, Formosa, and eastern China.

GONOMYIA (PTILOSTENA) METATARSATA ATROPHIA subsp. nov. Plate 1, fig. 13.

*Female.*—Length, about 6 millimeters; wing, 5; foreleg, tibia, 4.6, basitarsus, 2.8.

Characters as in typical *metatarsata* de Meijere (India to Java), differing especially in the intense blackened tips of the femora and the partly atrophied vein $R_4$ of the wings.

Legs yellow, the tips of all femora narrowly but very conspicuously blackened; tibiæ similar, the tips more narrowly blackened. Wings (Plate 1, fig. 13) narrow; most of vein $R_4$ atrophied, in the type with only a basal spur that is a little longer than $R_3$, with three macrotrichia on spur; cell 2d A much wider than indicated by de Meijere's figure of the typical form.[10] Abdomen of type female uniformly blackened, only the genital region paler.

LUZON, Tayabas Province, Lucban, January 29, 1931 (*Rivera*); holotype, female.

The exact status of this fly is still in question. The partly atrophied condition of vein $R_4$ of the wings is apparently a normal one, inasmuch as it was reported also by Edwards in a male specimen from Dumaguete, Negros.[11]

[10] Tijd. voor Entom. 54 (1911) pl. 3, fig. 35.

[11] Notulæ Entomologicæ 6 (1926) 37, as *metatarsata.*

**GONOMYIA (GONOMYIA) PAUAIENSIS** sp. nov. Plate 1, fig. 14; Plate 2, fig. 33.

Belongs to the *subcinerea* group; mesonotum brownish black, the median area of scutum and the scutellum yellow; antennæ and legs black; wings faintly tinged with brown, the stigmal region darker; $Sc_1$ ending about opposite one-fifth the length of Rs; male hypopygium with the dististyle a flattened blade that bears a single powerful black spine on outer margin, the broad apex of style terminating in two setæ.

*Male.*—Length, about 4.5 millimeters; wing, 5.3.

*Female.*—Length, about 6 millimeters; wing, 5.8.

Rostrum brownish black; palpi black. Antennæ black throughout, relatively elongate, especially in female. Head dark gray, brighter on occiput.

Pronotum orange-yellow. Anterior lateral pretergites light yellow. Mesonotal præscutum brownish black, sparsely pruinose, the humeral region restrictedly brightened; scutal lobes black, the median region obscure yellow; separated from the deep yellow scutellum by a narrow blackish line crossing the posterior border; mediotergite black, pruinose. Pleura and pleurotergite almost entirely pale yellow, variegated by blackish gray on the anepisternum and sternopleurite. Halteres elongate, dusky, the base of stem yellow, the knobs obscure brownish yellow to pale brown. Legs with the coxæ brown, more or less yellow apically; trochanters brown; remainder of legs black. Wings (Plate 1, fig. 14) with a faint brown tinge, the stigmal region darker; veins brownish black. Costal fringe of male moderate in length. Venation: $Sc_1$ ending about opposite one-fifth the length of Rs, $Sc_2$ a short distance from its tip; m-cu at fork of M.

Abdominal tergites dark brown, sternites brownish yellow. Male hypopygium (Plate 2, fig. 33) with the tergite, *9t*, deeply bilobed, each lobe with a lateral pencil of setæ. Shorter apical lobe of basistyle, *b*, relatively small, pale, with several elongate setæ that about equal the lobe in length; longer lobe of basistyle, *b*, fleshy, the apex a little dilated into a blade, the mesal edge of which is without setæ. Dististyle, *d*, with a powerful curved black spine on outer margin at near midlength, this with a single seta at near one-third the length; body of style terminating in two fasciculate setæ, the disk with about five setæ on one face and eight on the other. Ædeagus, *a*, subtended by two very unequal spines, the longest of which is blackened along edge, the short one a small pale spike.

LUZON, Mountain Province, Benguet, Haight's Place, Pauai, altitude 8,000 feet, October 6, 1931 (*Clagg and Rivera*) ; holotype, male; allotype, female.

*Gonomyia* (*Gonomyia*) *pauaiensis* is very similar to other species of the subgenus in Formosa and the Philippines, differing in the structure of the male hypopygium, especially the conformation of the dististyle. By my key to the Philippine species of *Gonomyia*[12] the fly runs to *G.* (*G.*) *nebulicola* Alexander (Mindanao), at that time the only member of the subgenus known from the Islands.

**GONOMYIA (GONOMYIA) GRATILLA** sp. nov. Plate 1, fig. 15; Plate 2, fig. 34.

Belongs to the *subcinerea* group; general coloration of mesonotum dark brown; pleura chiefly pale, the anepisternum darker; rostrum obscure yellow; legs brownish black; wings grayish subhyaline; stigma pale brown, faintly indicated; $Sc_1$ ending opposite origin of Rs; cell 1st $M_2$ narrow; male hypopygium with the dististyle bearing a small fingerlike lobe near base; outer portion of style narrowed to an acute black point, on outer face before tip with two strong fasciculate setæ; phallosome with ædeagus narrow; pale; two slender pale apophyses, one shorter and very acute.

*Male.*—Length, about 3 millimeters; wing, 3.5.

Rostrum obscure yellow, palpi black. Antennæ black; flagellar segments elongate, with abundant dense erect setæ. Head dark gray.

Anterior lateral pretergites obscure yellow. Mesonotal præscutum dark brown medially, somewhat paler on sides; median region of scutum obscure yellow; scutellum obscure yellowish testaceous; mediotergite brown. Pleura chiefly pale, the anepisternum darker. Halteres relatively elongate, dark brown, the base of stem pale. Legs with the coxæ obscure yellow, the fore coxæ darker; trochanters obscure yellow; remainder of legs brownish black. Wings (Plate 1, fig. 15) grayish subhyaline; stigma pale brown, faintly indicated; veins brown; macrotrichia long and abundant, black. Venation: $Sc_1$ ending opposite origin of Rs; r-m long, gently arcuated, placed at or just before fork of Rs, in alignment with $R_5$ the basal deflection of the latter obliterated; m-cu at fork of M; cell 1st $M_2$ narrow.

[12] Philip. Journ. Sci. 48 (1932) 615–617.

Abdomen dark brown; hypopygium obscure yellow. Male hypopygium (Plate 2, fig. 34) with the outer lobe of basistyle, *b*, a little expanded on mesal portion. Dististyle, *d*, with a slender fingerlike lobe near base, this tipped with a single strong seta; outer portion of style slender, blackened, narrowed to an acute point, before apex on outer face with two strong fasciculate setæ arising close together, the outermost only about two-thirds the length of the inner or lower seta. Phallosome, *p*, consisting of the unusually narrow, pale ædeagus, and two unequal pale apophyses, one shorter and much slenderer than the second, needlelike.

MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, May 27, 1931 (*Clagg*); holotype, male; allotype, female; paratypes, females.

*Gonomyia* (*Gonomyia*) *gratilla* is very different from the other members of the group in the structure of the dististyle and the entirely pale phallosome. It is much smaller than all other Oriental members of the group, with the exception of *G.* (*G.*) *longifimbriata* sp. nov., which differs in the long costal fringe of the wings and in the structure of the male hypopygium.

GONOMYIA (GONOMYIA) LONGIFIMBRIATA sp. nov. Plate 1, fig. 16; Plate 2, fig. 35.

Belongs to the *subcinerea* group; size small (wing, male, 3.5 millimeters); general coloration of notum brown; pleura brown, the pteropleurite paler; legs black; wings with a faint gray tinge; costal fringe (male) very long and conspicuous; m-cu before fork of M; male hypopygium with the dististyle bearing a long slender outer lobe and a flattened inner blade that has two curved black spines.

*Male.*—Length, about 3 millimeters; wing, 3.5.

Rostrum and palpi brownish black. Antennæ black throughout; flagellar segments long-oval, with elongate verticils. Head dark.

Anterior lateral pretergites restrictedly pale yellow. Mesonotum uniformly brown. Pleura brown, the pteropleurite abruptly paler. Halteres broken. Legs with the coxæ and trochanters brownish testaceous; remainder of legs black. Wings (Plate 1, fig. 16) with a faint gray tinge; veins brown. Costal fringe (male) very long and conspicuous, only a little shorter, though stouter, than the posterior fringe. Venation: Sc ending just before the origin of Rs, $Sc_2$ a short distance beyond the end of $Sc_1$, immediately opposite origin of Rs; Rs in alignment with $R_5$, the basal section of the latter lacking; $R_3$ relatively short,

about one-third longer than distance on margin between tips of veins $R_{1+2}$ and $R_3$; m-cu before fork of M.

Abdomen brownish black; hypopygium somewhat brighter. Male hypopygium (Plate 2, fig. 35) with the dististyle, *d,* divided into two parts, an outer slender fleshy arm, with long conspicuous setæ along its entire length; and a stouter blade that bears a powerful curved black spine on outer margin at near midlength; apex of lobe with a small, less curved, black spine, on apical margin below which are two powerful fasciculate setæ; face of lobe with a linear series of about six long setæ. Phallosome, *p,* with two slender arms at near midlength, both arms ending in slender spines .

MINDANAO, Cotabato Province, Cornadal, April 19, 1932 (*Rivera*) ; holotype, male.

The small size, long costal fringe of male, and construction of the male hypopygium readily separate the present fly from other Indo-Malayan species of the subgenus.

**GONOMYIA (GONOMYIA) VERSICOLOR sp. nov. Plate 1, fig. 17.**

Belongs to the *cognatella* group; general coloration of thoracic notum a medium brown; pleura striped longitudinally with whitish; knobs of halteres dusky; legs dark brown; wings brownish, the disk conspicuously variegated by subhyaline areas before and beyond cord; stigma dark brown; paler brown seams along cord; abdomen brownish black, the segments ringed caudally with whitish.

*Female.*—Length, about 3.3 to 3.8 millimeters; wing, 3.5 to 4.2.

Rostrum and palpi black. Antennæ with basal two segments yellow beneath, darker above; flagellum black. Head above chiefly pale, the center of vertex more or less darkened.

Anterior lateral pretergites and pronotum light yellow. Mesonotum almost uniform medium brown, the præscutum a little darker sublaterally; scutellum not brightened. Pleura dark brown, conspicuously striped longitudinally with a ventral whitish stripe extending from the fore coxæ to the base of abdomen, passing beneath the halteres. Halteres obscure whitish, the knobs dusky. Legs with the coxæ obscure testaceous, the fore coxæ white, as described; remainder of legs dark brown. Wings (Plate 1, fig. 17) with the ground color brownish, especially the apical region, the disk conspicuously variegated by extensive subhyaline areas before and beyond cord; stigma dark brown, very conspicuous; distinct but paler brown clouds along

cord and fork of $M_{1+2}$; veins pale brown, darker in the clouded areas. Venation: $Sc_1$ ending just beyond origin of Rs, $Sc_2$ at its tip; m-cu close to fork of M.

Abdominal segments brownish black, the caudal borders narrowly ringed with whitish. Ovipositor with genital shield blackened, the elongate valves brownish yellow.

MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 27, 1931 (*Clagg*); holotype, female; paratype, female.

*Gonomyia* (*Gonomyia*) *versicolor* is closest to *G.* (*G.*) *obscuriclava* Alexander (Sumatra), differing in the details of coloration, most conspicuously in the highly variegated wing pattern of the present fly. Unfortunately the male of neither of these species is available for comparison.

**GONOMYIA (LIPOPHLEPS) PERREDUCTA** sp. nov. Plate 1, fig. 18; Plate 3, fig. 36.

Mesonotal præscutum brownish black medially, paler brown sublaterally, the borders yellow; knobs of halteres obscure yellow; legs black; wings with a pale brown tinge; cell $R_3$ present but very small; macrotrichia on nearly the whole length of both anal veins; male hypopygium large and very complex in structure, the inner dististyles of the two sides quite different in construction; outer lobe of basistyle of each side very long and fingerlike.

*Male.*—Length, about 3.5 millimeters; wing, 3.8 to 4.

*Female.*—Length, about 4.5 millimeters; wing, 4.5.

Rostrum dark brown; palpi black. Antennæ black throughout; flagellar segments of male with long conspicuous verticils on segments five to nine, inclusive, the other flagellar segments with shorter verticils; longest verticils approximately three times as long as the segments that bear them. Head blackened, the central portion of the occipital region brighter.

Pronotum and anterior lateral pretergites yellow. Mesonotal præscutum brownish black medially, paler brown away from the central area; humeral and lateral portions of præscutum obscure yellow; scutal lobes and a transverse area on posterior portion of median area of scutum dark brown; remainder of median area of scutum and the scutellum yellow; mediotergite yellow on cephalic half, more reddish on posterior portion. Pleura and pleurotergite yellow, the anepisternum and sternopleurite somewhat more infumed. Halteres with stem dusky, obscure yellow at base, the apices of the knobs light yellow. Legs with the fore coxæ darkened, the remaining coxæ and all trochanters yellow;

remainder of legs black, the femoral bases restrictedly pale. Wings (Plate 1, fig. 18) with a pale brown tinge, cells C and Sc pale yellow, the stigmal region darker brown, diffuse; veins and macrotrichia brown. Costal fringe moderately long and conspicuous; macrotrichia of veins conspicuous, none on $R_3$; both anal veins with trichia except at their bases. Venation: $Sc_1$ ending opposite origin of Rs or nearly so, $Sc_2$ close to its tip; vein $R_3$ present, oblique to suberect, cell $R_2$ at margin subequal to cell $R_3$; Rs shorter than petiole of cell $R_3$; m-cu close to fork of M.

Abdominal tergites chiefly brown, the caudal and lateral borders of the segments brightened; sternites chiefly light yellow. Male hypopygium (Plate 3, fig. 36) with the dististyle, *d*, and phallosome, *p*, highly asymmetrical, large and complex in structure. Basistyle, *b*, alike on both sides, the lobe very long, pale, cylindrical, clothed with long conspicuous setæ. Dististyle, *d*, of one side bearing two slender arms besides the fleshy innermost one that terminates in a single powerful fasciculate seta, and, in addition, bears the usual elongate seta on outer face at near two-thirds the length; longest arm of this style strongly curved and convoluted. Dististyle, *d*, of the opposite side bearing a single arm additional to the inner, fleshy, bristle-bearing arm, which is quite like its mate of the opposite side. Phallosome, *p*, consisting of three yellowish blades, of which one is much longer, compressed, hanging pendant from the genital chamber like a cleaver.

MINDANAO, Cotabato Province, Mount Matutum, April 9 to 27, 1932 (*Rivera*), holotype, male; allotype, female; paratypes, both sexes; Barrio Lagdaan, April 4, 1932 (*Rivera*); paratypes, both sexes; Nupol, April 2, 1932 (*Rivera*); paratypes, both sexes.

The other regional species of the subgenus having cell $R_3$ present (*nubeculosa* de Meijere and *pallidisignata* Alexander) have the wings conspicuously patterned with dark and light colors, and the femora conspicuously ringed with black before the tips. The present fly is very distinct from other Oriental species of *Gonomyia* in the unusually small cell $R_3$ and the large complex male hypopygium, with asymmetrical dististyles. By my key to the Philippine species of the genus,[13] the fly runs to *pallidisignata.*

[13] Philip. Journ. Sci. 48 (1932) 615–617.

**GONOMYIA (LIPOPHLEPS) PINIVAGATA** sp. nov. Plate 1, fig. 19; Plate 3, fig. 37.

Belongs to the *skusei* group; size large (wing, 5 millimeters or more); antennæ black throughout, in male, the flagellar segments long-cylindrical, with abundant outspreading erect setæ; pleura conspicuously striped longitudinally with white; wings with a strong brownish tinge; abdominal tergites dark brown, sternites yellow; male hypopygium with the dististyle single, entirely fleshy; phallosome terminating in four obtuse points, the surface with conspicuous erect setæ.

*Male.*—Length, about 4 to 4.2 millimeters; wing, 5 to 5.3.

*Female.*—Length, about 4.2 millimeters; wing, 5.

Rostrum brownish black, more obscure yellow on sides; palpi black. Antennæ black throughout; flagellar segments (male) long-cylindrical, with abundant outspreading erect setæ. Head gray.

Pronotum and anterior lateral pretergites whitish. Mesonotum dark brown or brownish black, the scutellum, broad median area of scutum, and posterior angles of scutal lobes yellow; mediotergite more pruinose, the cephalic-lateral portion and dorsal half of pleurotergite yellow. Pleura dark brown, with a conspicuous white longitudinal stripe extending from behind the fore coxæ to the base of abdomen. Halteres brown, the base of stem and apex of knob slightly brightened. Legs with the coxæ and trochanters dark; remainder of legs brownish black. Wings (Plate 1, fig. 19) with a strong brownish tinge, the stigmal region very vaguely darker; veins dark brown. Venation: Sc long, $Sc_1$ ending about opposite one-third to two-fifths the length of Rs, $Sc_2$ at near mid-distance between origin of Rs and tip of $Sc_1$; outer radial veins elongate; basal section of $R_5$ short; cell $R_5$ narrowed at margin; m-cu at or close to fork of M.

Abdominal tergites dark brown, sternites yellow. Male hypopygium (Plate 3, fig. 37) with a single fleshy dististyle, *d*, this subequal in length and size to the apical lobe of basistyle, *b*, terminating in a powerful fasciculate seta and with one unusually long seta on outer face at near two-thirds the length, in addition to the more normal setæ. Phallosome, *p*, with four obtuse points at apex, with two slender darkened rods or tubes extending almost the entire length of the structure; surface of phallosome with conspicuous scattered setæ.

LUZON, Mountain Province, Benguet, Haight's Place, Pauai, altitude 8,000 feet, in pine forest (*Pinus insularis* Endlicher) (*Clagg and Rivera*), October 5–6, 1931; holotype, male; allotype, female; paratypes, both sexes, October 2 to 6, 1931; Clark's

Place, Camp 66, altitude 7,000 feet, October 6, 1931 (*Clagg and Rivera*); paratypes, both sexes.

*Gonomyia* (*Lipophleps*) *pinivagata* is the largest species of the *skusei* group in the Oriental Region, being fully equal in size to the typical species, *G.* (*L.*) *skusei* Alexander, of eastern Australia. It is readily told from other allied species by the structure of the phallosome of the male hypopygium.

**GONOMYIA (LIPOPHLEPS) RAMIFERA** sp. nov. Plate 1, fig. 20; Plate 3, fig. 38.

Allied to *jacobsoniana;* male hypopygium with the middle dististyle biramous, both arms densely covered with conspicuous setæ; inner dististyle a long slender rod, hinged at base, the distal third with numerous scattered erect setæ.

*Male.*—Length, about 3.5 to 3.6 millimeters; wing, 2.9 to 3.2.

*Female.*—Length, about 3.8 to 4 millimeters; wing, 3.2 to 3.4.

Rostrum and palpi black. Antennæ with basal two segments dark above, yellow beneath; flagellum brownish black. Head light yellow, the posterior vertex extensively variegated with dark brown.

Pronotum and anterior lateral pretergites light yellow. Mesonotal præscutum and scutum brown, bordered laterally by a narrow, more blackish line; pseudosutural foveæ black; scutellum dark, broadly bordered by light yellow; mediotergite dark gray. Pleura dark gray, with a conspicuous whitish longitudinal stripe extending from fore coxæ to the base of abdomen. Halteres obscure yellow, the knobs dusky. Legs with the fore coxæ pale, remaining coxæ darkened; trochanters brownish yellow; femora brownish yellow, the fore and middle femora with black terminal rings, the posterior femora with these rings subterminal; dark femoral annuli preceded by a narrow, more yellowish annulus; tibiæ yellow, the extreme bases blackened, narrowest and least distinct on the posterior tibiæ; tips of tibiæ narrowly blackened; tarsi obscure yellow, the tips of basitarsi and second segment, and all of remaining segments darkened. Wings (Plate 1, fig. 20) grayish subhyaline, virtually immaculate, the stigma scarcely indicated; veins pale brown, the cord somewhat darker. Venation: $Sc_1$ ending just before origin of Rs; basal section of $R_5$ elongate; m-cu varying in position from close to fork of M to about two-thirds its length before this fork.

Abdominal tergites black, the caudal borders (male) narrowly obscure whitish; sternites uniformly blackened. Male hypopygium (Plate 3, fig. 38) with three dististyles, the innermost, *id,* basal, almost in the usual position of an interbase.

Outer dististyle, *od*, a simple curved glabrous rod. Middle style, *md*, shorter, biramous by a slender branch at near two-thirds the length, this set with short spinous setæ; main axis of style stouter, with long coarse setæ. Inner style, *id*, very long and slender, hinged at base, but not provided with setæ at this point as in *jacobsoniana;* outer third of style with scattered conspicuous setæ. Phallosome, *p*, and asymmetrical mass.

MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 27, 1931 (*Clagg*); holotype, male; allotype, female; paratypes, several, both sexes.

The present fly is readily distinguished from the other described species that are allied to *Gonomyia* (*Lipophleps*) *diffusa* (de Meijere) by the structure of the male hypopygium, especially of the middle and inner dististyles.

**GONOMYIA (LIPOPHLEPS) JACOBSONIANA Alexander.**

*Gonomyia* (*Lipophleps*) *jacobsoniana* ALEXANDER, Philip. Journ. Sci. **53** (March, 1934).

MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 26–27, 1931 (*Clagg*). Known elsewhere from Sumatra.

**GONOMYIA (LIPOPHLEPS) LUTEIMARGINATA Alexander.**

*Gonomyia* (*Lipophleps*) *luteimarginata* ALEXANDER, Philip. Journ. Sci. **46** (1931) 32–33.

Described from Calian, Lawa, Mindanao, and now known to be widely distributed in the Austromalayan islands.

LUZON, Manila, at lamp, August 5, 1932 (*McGregor*); 1 male. NORTH CELEBES, Roeroekan, Minahassa, altitude 4,000 feet, at light, April 14, 1931 (*Clagg*); 1 male. NEW GUINEA, Seleo, Berlinhafen, 1896 (*Biró*); 2 males.

Riedel [14] had earlier determined the two last-mentioned specimens as being *Lipophleps brevivena* Skuse (No. 25) and *L. nebulosa* de Meijere (?) (No. 27). The specimens are in the Hungarian National Museum and were examined by me through the kindness of Doctor Szilady.

**GONOMYIA (LIPOPHLEPS) DIACANTHA sp. nov. Plate 3, fig. 39.**

Allied to *luteimarginata;* general coloration dark grayish brown, the scutellum chiefly yellow; pleura blackish gray, with a broad whitish longitudinal stripe; legs brownish yellow to brown; wings variegated with pale brown and subhyaline areas, the costal region clear light yellow; Sc short; abdominal tergites

[14] Ann. Mus. Nat. Hungarici **18** (1920) 136.

uniformly dark brown; male hypopygium with both dististyles terminal in position, the outer bearing two black teeth or spines near base of mesal face.

*Male.*—Length, about 2.3 to 2.5 millimeters; wing, 2.8 to 3.1.

*Female.*—Length, about 2.8 to 3 millimeters; wing, 3.2 to 3.3.

Rostrum and palpi black. Antennæ black, the upper surface of the basal two segments obscure yellow. Head yellow, the center of vertex darkened.

Anterior lateral pretergites and lateral borders of præscutum pale yellowish white. Mesonotum dark grayish brown, the pseudosutural foveæ black; median region of scutum and posterior portions of lobes yellow; scutellum yellow, darkened medially at base; mediotergite chiefly darkened, yellow laterally, in cases with the yellow color continued subbasally across the sclerite. Pleura blackish, pruinose, with a broad whitish or yellowish white longitudinal stripe extending from the fore coxæ across the dorsal sternopleurite and meral region to the base of abdomen, passing beneath the halteres. Halteres dusky, the apex of knob obscure yellow. Legs with the coxæ dark, fore coxæ white, as described; trochanters obscure yellow; femora obscure brownish yellow to brown, deepening toward outer end; tibiæ and tarsi darkened. Wings clouded with pale brown and subhyaline areas, iridescent; cells C and Sc clear light yellow; stigma darker brown; subhyaline brightenings mostly before and beyond cord and in the outer ends of cubital and anal cells; veins pale, the cord and outer medial veins darker. Venation: Sc short, $Sc_1$ ending a distance before origin of Rs about equal to m-cu or two-thirds the length of Rs; veins of radial field strongly divergent; basal section of $R_5$ long; m-cu at fork of M.

Abdominal segments in both sexes uniform dark brown; sternites a very little paler; hypopygium orange. Male hypopygium (Plate 3, fig. 39) with the outer dististyle, *od,* bearing two teeth near base on mesal edge, the basal one longer and slenderer, the outer tooth separated from the first by a rounded or oval notch; remainder of style entire, blackened. Inner dististyle, *id,* shorter, strongly curved at near midlength, the apex narrowed into a slender black spine. Apical spines of gonapophyses long and slender, blackened.

MINDANAO, Cotabato Province, Nupol, March 29 to April 2, 1932 (*Rivera*); holotype, male; allotype, female; paratypes, several, both sexes; Barrio Lagdaan, April 4, 1932 (*Rivera*);

paratypes, males; Covell, Buayan, March 24 to 28, 1932 (*Rivera*); paratypes, males; Mount Matutum, April 9, 1932 (*Rivera*); paratypes, males.

Closely allied to *Gonomyia* (*Lipophleps*) *luteimarginata* Alexander (Luzon, Mindanao, Celebes, and New Guinea), differing evidently and conspicuously in the structure of the male hypopygium, such as the total lack of small spinules along mesal edge of outer dististyle, these being replaced by a single triangular blackened tooth near the basal spine, and in the quite different structure of the inner dististyles and gonapophyses.

**GONOMYIA (LIPOPHLEPS) SUBPILIFERA sp. nov.** Plate 1, fig. 21; Plate 3, fig. 40.

Belongs to the *pilifera* group; pleural stripe poorly defined; femora with inner dark annulus narrow and poorly indicated; wings whitish, with restricted brown areas and very pale gray washes on basal half; male hypopygium with the outer dististyle short, its apex a blackened point, with a small group of setæ close to tip.

*Male.*—Length, about 3.2 millimeters; wing, 2.8.

Rostrum and palpi blackish brown. Antennæ with scape and pedicel reddish brown; flagellum darker brown. Head brownish gray.

Mesonotal præscutum gray, the median portion weakly infuscated; pseudosutural foveæ black, conspicuous; posterior sclerites of mesonotum not visible in the unique type. Pleura brownish gray, with a clearer gray longitudinal stripe across the ventral sclerites. Halteres dusky, the base of stem narrowly orange, the knobs obscure. Legs with femora obscure yellow, with a broad brownish black subterminal ring and indications of a second, narrow, pale brown ring at near two-thirds the length of the segment; tibiæ obscure yellow, the tips narrowly dark brown; basitarsi obscure yellow, the tips and remainder of tarsi blackened. Wings (Plate 1, fig. 21) whitish, with a restricted brown pattern, as in the group; restricted brownish areas at arculus, tip of Sc and origin of Rs, tip of $R_3$, and along cord and outer end of cell 1st $M_2$; stigma oval, somewhat paler grayish brown; paler gray washes across basal half of wing; veins pale, darker in the clouded areas. Venation: $Sc_1$ ending opposite origin of Rs, $Sc_2$ at its tip; m-cu before fork of M.

Abdominal segments dark brown, ringed caudally with paler; hypopygium obscure yellow. Male hypopygium (Plate 3, fig. 40) with the characters as in group, inner dististyle, *id*, with a

densely setiferous pale cushion at base; basistyle, *b*, with pale digitiform lobe on mesal face; phallosome, *p*, produced into two slender needlelike spines. Differs from *pilifera* in the short outer dististyle, *od*, which is only slightly arcuated, immediately before tip with a small group of setæ, the apex beyond this point a short black spine. Ædeagus a slender dark spine, provided with small appressed setulæ.

MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 26, 1931 (*Clagg*); holotype, male.

Differs from *Gonomyia* (*Lipophleps*) *pilifera* (de Meijere), of Java and Sumatra, in the structure of the male hypopygium.

**GONOMYIA (LIPOPHLEPS) INÆQUISTYLA** sp. nov. Plate 1, fig. 22; Plate 3, fig. 41.

General coloration of notum dark brown; pleura variegated with brown and whitish, not striped longitudinally; legs dark brown to brownish black; wings with a faint brown tinge, unmarked except for the pale brown stigma; Sc short; male hypopygium with the dististyle of either side very different in structure from its mate of the opposite side.

*Male.*—Length, 2.7 to 2.8 millimeters; wing, 3 to 3.2.

*Female.*—Length, about 3 to 3.2 millimeters; wing, 3.2 to 3.4.

Rostrum obscure yellow; palpi dark. Antennæ dark throughout; verticils unsually abundant and elongate. Head dark gray.

Anterior lateral pretergites very restrictedly whitish. Mesonotum brown, darker brown medially, the humeral and lateral regions of præscutum more brightened; median region of scutum and the scutellum obscure yellow, the latter darkened medially at base; mediotergite darkened, pleurotergite pale yellow. Pleura variegated dark brown and whitish but without longitudinal pale stripes, as usual in the subgenus, the pattern more transversely tessellated; the pale color includes the dorsopleural region, posterior sternopleurite, and lower posterior angle of anepisternum, together with the meral region; the dark color includes most of anepisternum and sternopleurite, and the pteropleurite. Halteres dusky, the stem brighter at base. Legs with the coxæ dark brown; trochanters obscure brownish yellow; femora brownish black, the tibiæ and tarsi slightly paler brown. Wings (Plate 1, fig. 22) with a faint brown tinge, the stigmal region a little darker; veins dark brown. Venation: $Sc_1$ ending some distance before origin of the short Rs, $Sc_2$

some distance from its tip; Rs and anterior branch of same subequal, or the latter a little longer; r-m unusually long and arcuated, the basal section of $R_5$ correspondingly reduced.

Abdominal tergites dark brown, the sternites similar, narrowly bordered laterally and caudally with pale; hypopygium obscure yellow. Male hypopygium (Plate 3, fig. 41) with the dististyles of the two sides very different in structure; one, *d*, a small oval flattened plate, shorter than the apical lobe of basistyle, produced laterad into a curved black spine; dististyle of opposite side, *d*, much longer than the lobe of basistyle, slender, gently curved, the tip a narrow blackened spine with numerous setæ surrounding base of spine; on basal half a series of seven or eight long erect setæ.

MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 27, 1931 (*Clagg*); holotype, male; allotype, female; paratypes, several of both sexes. NORTH CELEBES, Minahassa, Roeroekan, altitude 3,500 feet, April 11, 1931 (*Clagg*); paratype, male.

The species most similar to this in the Oriental fauna is *Gonomyia* (*Lipophleps*) *incompleta* Brunetti, which is readily separated by the symmetrical dististyles of the male hypopygium. Asymmetrical dististyles are frequent in New Zealand and certain Neotropical members of *Lipophleps*, but the present case marks the greatest extreme known to me, with the single exception of *G.* (*L.*) *perreducta* sp. nov., described in this paper.

### Genus ERIOPTERA Meigen

*Erioptera* MEIGEN, Illiger's Magaz. 2 (1803) 262.

#### Subgenus METERIOPTERA subg. nov.

Characters as in typical *Erioptera*, differing as follows: Basal three or four segments of antennal flagellum united into a short, truncate-conical fusion segment (Plate 3, fig. 42), the entire organ thus with twelve or thirteen segments. Wings with cord beyond midlength (Plate 1, figs. 23 and 24); vein 2d A only moderately sinuous, the distal fourth deflected slightly cephalad and not strongly constricting cell 1st A. Male hypopygium (Plate 3, figs. 43, 44, and 45) with the outer dististyle, *od*, terminating in a group of appressed spinous setæ or spines; inner dististyle, *id*, with apical portion usually bent at a strong angle to main axis of style.

*Type of subgenus.*—*Erioptera javanensis* de Meijere (Oriental: Austromalayan).

Other included species: *Erioptera angustifascia* Alexander (North Queensland), *E. fervida* sp. nov., *E. festiva* sp. nov., *E. geniculata* Edwards (Borneo and Mindanao), and *E. notata* de Meijere, with allied species or races (Oriental). All of the above forms, with the exception of *fervida* and *notata,* sens. lat., have the tips of the femora narrowly and abruptly white, preceded by a more or less distinct darkened annulus. *Erioptera rogersi* Alexander (Formosa), which has whitened femoral tips, does not belong to this new group but is a true *Erioptera.*

**ERIOPTERA (METERIOPTERA) FESTIVA sp. nov. Plate 1, fig. 23; Plate 3, figs. 42 and 43.**

Mesonotum chiefly cinnamon to light brown, the caudal borders broadly pale; femora yellow, with a brown subterminal ring, the tips white; wings yellow, with brown seams at origin of Rs, along cord and at tip of $R_{1+2}$; male hypopygium with the outer half of inner dististyle bent at an obtuse angle, the tip a blackened spine.

*Male.*—Length, about 2.5 millimeters; wing, 3.3.

*Female.*—Length, about 3 to 3.2 millimeters; wing, 3.5.

Rostrum yellow; palpi dark brown. Antennæ with the large scape and pedicel dark brown, the flagellum paler, especially the basal segments; ten flagellar segments beyond the conical fusion segment (Plate 3, fig. 42). Head pale brown.

Pronotum pale yellow. Mesonotum light cinnamon to pale brown, the humeral region and lateral borders of præscutum broadly whitish. Pleura chiefly brown, light in female, darker in male, variegated by silvery white on anepisternum, posterior portion of sternopleurite, meral region, and beneath the wing root. Halteres chiefly pale, the knobs weakly darkened, especially in the female. Legs with coxæ pale, the fore coxæ somewhat darker; trochanters yellow; femora yellow, with a conspicuous brown to dark brown subterminal ring a little more than its own length before the white tips; remainder of legs pale yellow, the outer tarsal segments a trifle paler. Wings (Plate 1, fig. 23) yellow, sparsely patterned with brown, including a conspicuous seam along cord, a common brown spot at origin of Rs and on $Sc_2$, and a spot at tip of $R_{1+2}$; a much fainter, barely evident, area at tip of vein $R_3$; veins yellow, darker in the clouded areas.

Abdominal tergite chiefly yellow, in male with a brown subterminal ring; in female, the segments more or less bicolored, dark basally, the caudal borders brighter; hypopygium yellow. Male hypopygium (Plate 3, fig. 43) with the inner dististyle, *id,*

stout, the distal half bent at an obtuse angle, the basal end of the bent portion with a flattened flange, the apex a blackened spine. Outer angles of phallosomic plate dusky, weakly corrugated.

MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 26–27, 1931 (*Clagg*); holotype, male; allotype, female; paratypes, 3 females.

*Erioptera* (*Meterioptera*) *festiva* is amply distinct from the other species of the subgenus, especially in the heavier wing pattern and in the structure of the male hypopygium. The distinctions between the three allied members of the subgenus in the Philippines having the femoral tips white are best shown by the following key:

1. Wings unmarked (Java, Borneo, and Mindanao). *javanensis* de Meijere.
   Wings with at least the cord and origin of Rs seamed with darker........ 2.
2. Small brown marginal spots at ends of veins $R_{1+2}$ and $R_3$ (Mindanao). *festiva* sp. nov.
   No dark markings at ends of veins $R_{1+2}$ and $R_3$ (Borneo and Mindanao). *geniculata* Edwards.

**ERIOPTERA (METERIOPTERA) JAVANENSIS de Meijere.**

*Erioptera javanensis* DE MEIJERE, Tijd. voor Entom. 54 (1911) 45–46, pl. 3, fig. 28 (male hypopygium).

Described from Java. MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 26–27, 1931 (*Clagg*); Cotabato Province, Buayan, May 8, 1932 (*Rivera*).

**ERIOPTERA (METERIOPTERA) GENICULATA Edwards.**

*Erioptera geniculata* EDWARDS, Journ. Fed. Malay States Mus. 16 (1931) 498–499.

Described from Bettotan, North Borneo. MINDANAO, Davao district, Tagum, Madaum River, at trap lantern, March 26–27, 1931 (*Clagg*), several specimens. The male hypopygium (Plate 3, fig. 44) is very similar to that of *javanensis*, but the spinous points at apex of outer dististyle, *od*, appear to be more delicate and more numerous. *Erioptera* (*Meterioptera*) *angustifascia* Alexander,[15] from North Queensland, is very similar to *geniculata* and may prove to be the same. The male sex is unknown and it is definitely unsafe to place virtually any described crane fly as a synonym without a knowledge of the male hypopygium.

[15] Proc. Roy. Soc. Queensland 32 (1920) 96–97.

**ERIOPTERA (METERIOPTERA) FERVIDA sp. nov. Plate 1, fig. 24; Plate 3, fig. 45.**

General coloration dull black, including halteres and legs; wings with a blackish suffusion; outer end of vein 2d A only shortly sinuous; male hypopygium with the inner dististyle stout, bent at a right angle into a powerful spine.

*Male.*—Length, about 2.5 millimeters; wing, 2.9 to 3.

Rostrum and palpi dull black. Antennæ with scape brown; pedicel brownish black; flagellum paler, more yellowish brown; flagellar segments beyond the fusion with long conspicuous verticils. Head brownish black.

Thorax uniformly blackened, opaque. Halteres and legs blackened. Wings (Plate 1, fig. 24) with a blackish suffusion; veins and macrotrichia still darker. Macrotrichia of veins long and coarse. Venation: Forks of radial and medial cells relatively shallow; $R_{2+3+4}$ fully twice r-m; m-cu shortly before fork of M; outer end of vein 2d A only slightly sinuous.

Abdomen black. Male hypopygium (Plate 3, fig. 45) with the outer dististyle, *od*, weakly clavate, the apex set with coarse short spines. Inner dististyle, *id*, bent at a right angle at near midlength, the apex a powerful spine, the inner margin roughened by microscopic papillæ. Gonapophyses, *g*, appearing as slender, curved blackened hooks.

MINDANAO, Cotabato Province, Pauayan, May 8, 1932 (*Rivera*); holotype, male; allotype, female; paratypes, both sexes.

The present fiy is undoubtedly allied to *javanensis*, despite the coloration of the body and appendages. Its general appearance is much like that of *Erioptera* (*Teleneura*) *fusca* de Meijere, but the two flies are distantly related.

The complex of races or closely allied species that center about *Erioptera* (*Meterioptera*) *notata* de Meijere belong to a different group from all the above, differing in the shape of the outer dististyle of the male hypopygium.

**ERIOPTERA (ERIOPTERA) BIARMATA sp. nov. Plate 3, fig. 46.**

General coloration pale reddish yellow; antennæ with segments of basal half pale, the outer segments darkened; halteres with blackened knobs; legs yellow; male hypopygium with the outer dististyle bifid beyond midlength into two acute black spines that diverge at an acute angle; inner dististyle simple; phallosome entirely pale.

*Male.*—Length, about 3.5 to 4 millimeters; wing, 4 to 4.8.

Rostrum yellow; palpi brownish black. Antennæ with scape, pedicel, and basal four or five flagellar segments yellow, the succeeding segments infuscated; flagellar segments subcylindrical to truncate-fusiform, the longest verticils subequal to the segments; antennæ 16-segmented, as normal. Head reddish yellow, the anterior vertex paler.

Pronotum yellowish. Mesonotum almost uniformly pale reddish, the posterior sclerites somewhat more reddish yellow. Pleura yellow. Halteres yellow, the knobs black. Legs yellow, the terminal tarsal segments weakly darkened. Wings yellow, the veins darker yellow; macrotrichia brown. Venation: Vein 2d A unusually long-sinuous, cell 1st A at midlength being more than twice as wide as just before outer end.

Abdomen brownish yellow, somewhat darker subterminally; hypopygium yellow. Male hypopygium (Plate 3, fig. 46) with the apex of basistyle, *b*, a little produced caudad beyond point of insertion of the dististyles; mesal face of style with dense erect setæ. Outer dististyle, *od*, bifid beyond midlength into two acute black spines that diverge at an acute angle, the outer or axial spine longer. Inner dististyle, *id*, simple, at apex slightly dilated into a spatula that is armed with several setigerous punctures. Phallosome appearing as two slender rods that are united at base to appear more or less like a tuning fork, each rod expanded laterad into a broad pale blade, the entire phallosomic region pale.

LUZON, Mountain Province, Benguet, Haight's Place, Pauai, altitude 8,000 feet, October 6, 1931 (*Clagg and Rivera*); holotype, male; paratypes, males, October 5–6, 1931.

Very similar in general appearance to *Erioptera* (*Erioptera*) *lunicola* Alexander (Luzon and Mindanao), differing in the immaculate wings and, especially, the very different structure of the male hypopygium, which is distinct from that of any other species known to me, suggesting in some respects a species of the subgenus *Empeda; E.* (*E.*) *cacuminis* Edwards, of the mountains of Borneo, has a hypopygium that somewhat resembles that of the present fly, but the outer dististyle and phallosome, especially the latter, are entirely different.

# ILLUSTRATIONS

[Legend: *a*, Ædeagus; *b*, basistyle; *d*, dististyle; *g*, gonapophysis; *id*, inner dististyle; *md*, middle dististyle; *od*, outer dististyle; *p*, phallosome; *t*, tergite.]

## PLATE 1

FIG. 1. *Limonia* (*Limonia*) *languida* sp. nov., wing.
2. *Limonia* (*Limonia*) *erratica* sp. nov., wing.
3. *Limonia* (*Limonia*) *melanoptera* sp. nov., wing.
4. *Limonia* (*Limonia*) *parvispiculata* sp. nov., wing.
5. *Limonia* (*Libnotes*) *circumscripta* sp. nov., wing.
6. *Limonia* (*Libnotes*) *rarissima* sp. nov., wing.
7. *Helius* (*Rhampholimnobia*) *brevinasus* sp. nov., wing.
8. *Trichoneura* (*Xipholimnobia*) *bontocensis* sp. nov., wing.
9. *Troglophila cotabatoensis* sp. nov., wing.
10. *Trentepohlia* (*Mongoma*) *carbonipes* sp. nov., wing.
11. *Trentepohlia* (*Mongoma*) *lætithorax* sp. nov., wing.
12. *Gonomyia* (*Ptilostena*) *cotabatoensis* sp. nov., wing.
13. *Gonomyia* (*Ptilostena*) *metatarsata atrophia* subsp. nov., wing.
14. *Gonomyia* (*Gonomyia*) *pauaiensis* sp. nov., wing.
15. *Gonomyia* (*Gonomyia*) *gratilla* sp. nov., wing.
16. *Gonomyia* (*Gonomyia*) *longifimbriata* sp. nov., wing.
17. *Gonomyia* (*Gonomyia*) *versicolor* sp. nov., wing.
18. *Gonomyia* (*Lipophleps*) *perreducta* sp. nov., wing.
19. *Gonomyia* (*Lipophleps*) *pinivagata* sp. nov., wing.
20. *Gonomyia* (*Lipophleps*) *ramifera* sp. nov., wing.
21. *Gonomyia* (*Lipophleps*) *subpilifera* sp. nov., wing.
22. *Gonomyia* (*Lipophleps*) *inæquistyla* sp. nov., wing.
23. *Erioptera* (*Meterioptera*) *festiva* sp. nov., wing.
24. *Erioptera* (*Meterioptera*) *fervida* sp. nov., wing.

## PLATE 2

FIG. 25. *Limonia* (*Limonia*) *languida* sp. nov., male hypopygium.
26. *Limonia* (*Limonia*) *erratica* sp. nov., male hypopygium.
27. *Limonia* (*Limonia*) *melanoptera* sp. nov., male hypopygium.
28. *Limonia* (*Limonia*) *parvispiculata* sp. nov., male hypopygium.
29. *Limonia* (*Libnotes*) *circumscripta* sp. nov., male hypopygium.
30. *Limonia* (*Libnotes*) *rarissima* sp. nov., male hypopygium.
31. *Trichoneura* (*Xipholimnobia*) *bontocensis* sp. nov., male hypopygium.
32. *Gonomyia* (*Ptilostena*) *cotabatoensis* sp. nov., male hypopygium.
33. *Gonomyia* (*Gonomyia*) *pauaiensis* sp. nov., male hypopygium.
34. *Gonomyia* (*Gonomyia*) *gratilla* sp. nov., male hypopygium.
35. *Gonomyia* (*Gonomyia*) *longifimbriata* sp. nov., male hypopygium.

PLATE 3

FIG. 36. *Gonomyia* (*Lipophleps*) *perreducta* sp. nov., male hypopygium.
37. *Gonomyia* (*Lipophleps*) *pinivagata* sp. nov., male hypopygium.
38. *Gonomyia* (*Lipophleps*) *ramifera* sp. nov., male hypopygium.
39. *Gonomyia* (*Lipophleps*) *diacantha* sp. nov., male hypopygium.
40. *Gonomyia* (*Lipophleps*) *subpilifera* sp. nov., male hypopygium.
41. *Gonomyia* (*Lipophleps*) *inæquistyla* sp. nov., male hypopygium.
42. *Erioptera* (*Meterioptera*) *festiva* sp. nov., antenna, male.
43. *Erioptera* (*Meterioptera*) *festiva* sp. nov., male hypopygium.
44. *Erioptera* (*Meterioptera*) *geniculata* Edwards, male hypopygium.
45. *Erioptera* (*Meterioptera*) *fervida* sp. nov., male hypopygium.
46. *Erioptera* (*Erioptera*) *biarmata* sp. nov., male hypopygium.

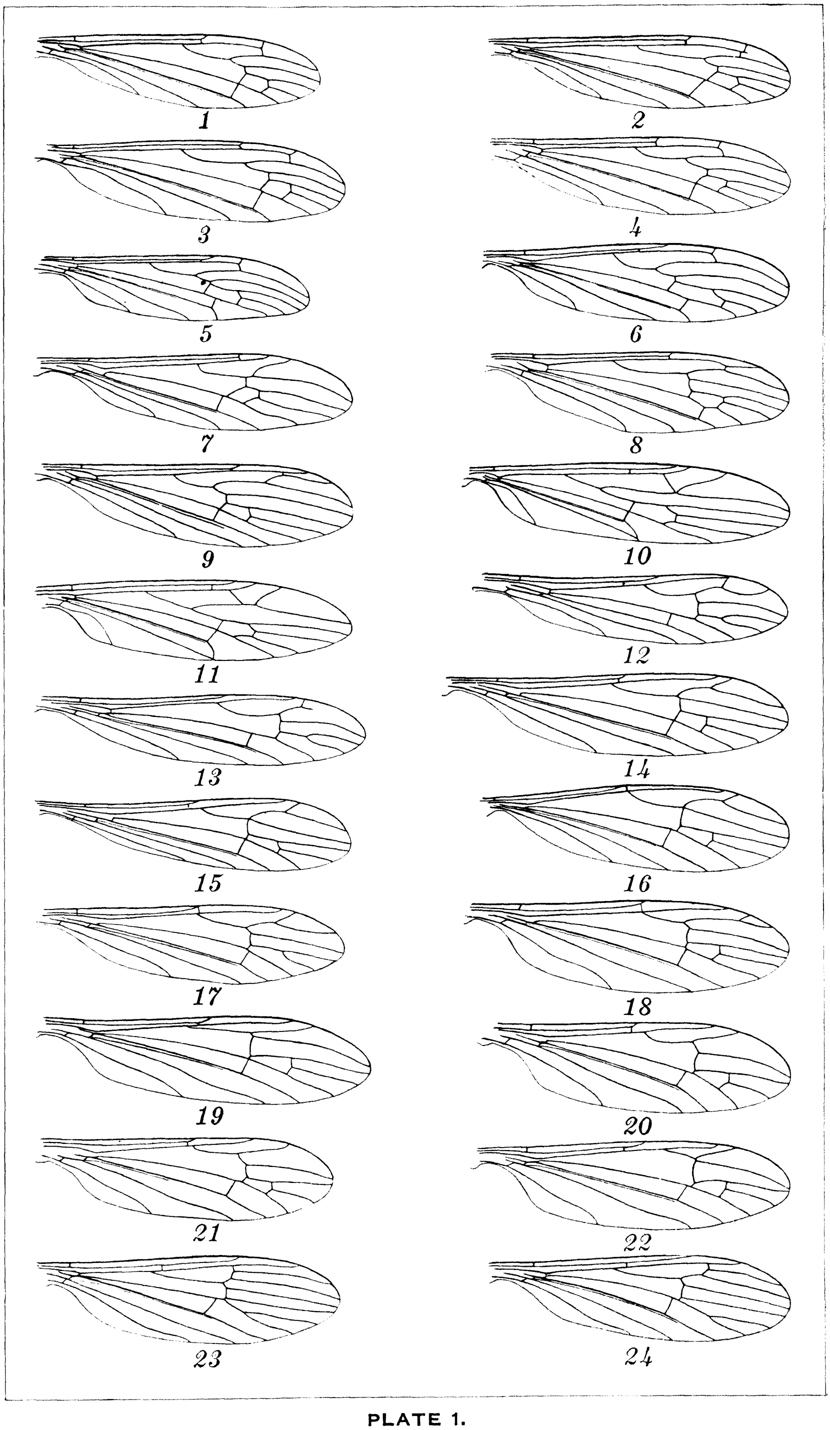


PLATE 1.

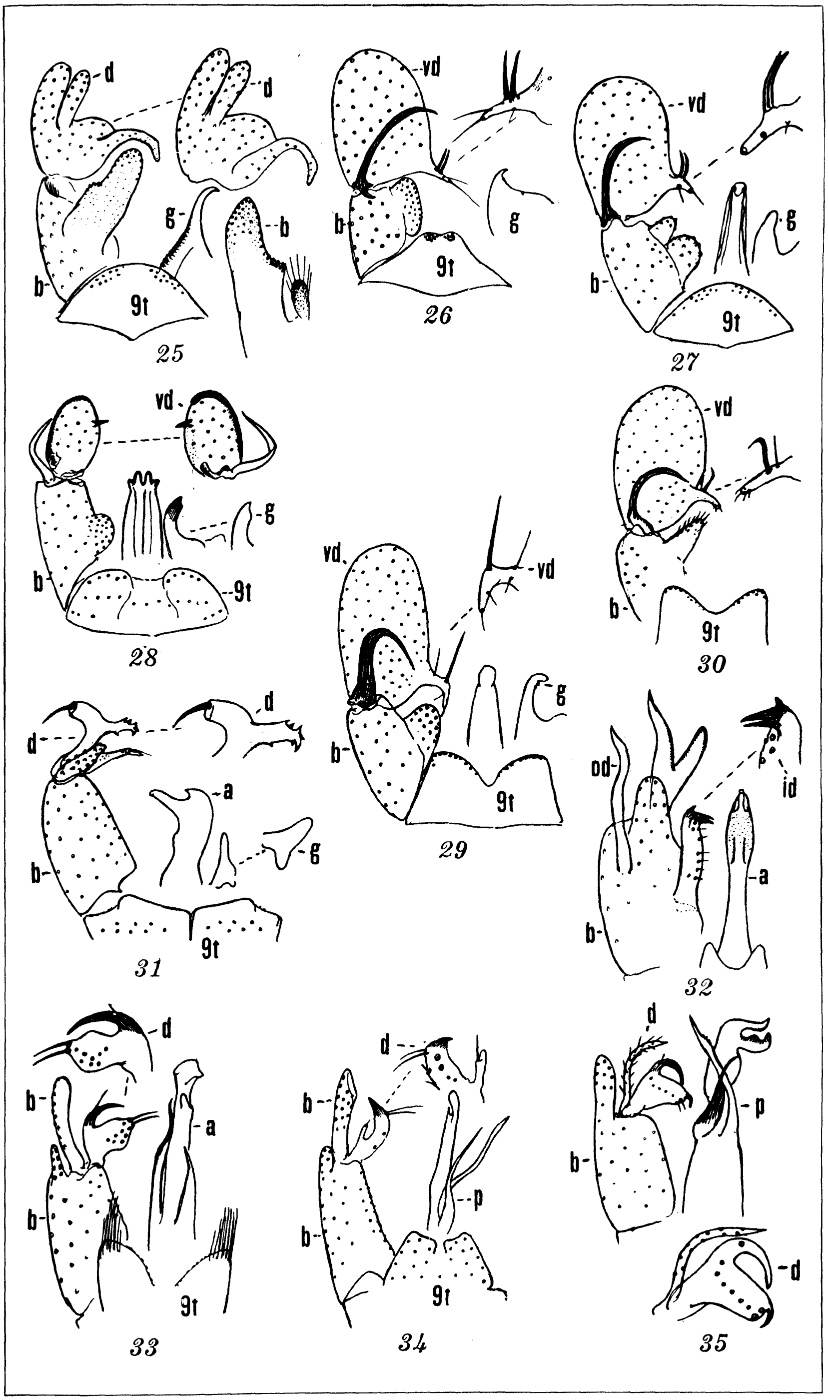
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PLATE 2.

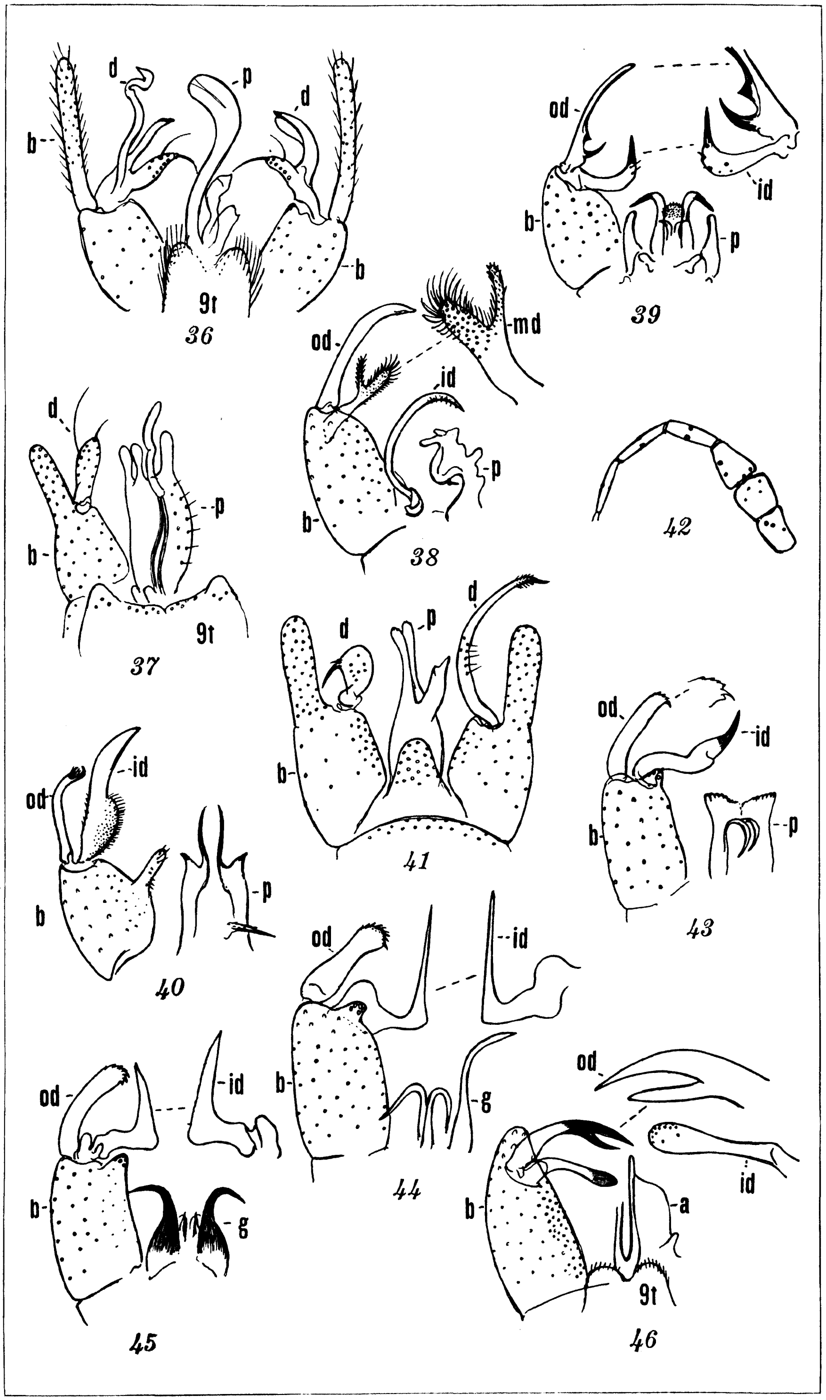
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PLATE 3.

# CHIRONOMIDÆ FROM JAPAN (DIPTERA), III

## THE EARLY STAGES OF A SEASHORE BITING MIDGE FORCIPOMYIA CRINUME (TOKUNAGA) [1]

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THREE PLATES

In 1932 I reported on a new biting midge collected from a shore plant, *Crinum asiaticum* var. *japonicum* (Amaryllidaceæ) and named it *Dasyhelea crinume*. On examining more extensive material I came to regard this species as properly belonging to the genus *Forcipomyia* sensu lato. The characteristic structures of the early stages of the present fly coincide almost perfectly with those of *Apelma* Kieffer, a special group of *Forcipomyia*, which was recently studied by Saunders (1925) in detail. Habits and habitat of the early stages of the present fly are also closely similar to those of the *Apelma* group, the young flies being found among the bases of succulent leaves of shore plants. As pointed out by Saunders, who placed this group in a separate genus, the dependable distinctive adult characters are, first, the characteristic H-shaped internal chitinization of the male hypopygium and, second, the absence of empodia in the male and their presence in the female; while in the present fly, although the first character is distinctly shown, the empodia of both sexes are all well developed as in the other *Forcipomyia* species. Edwards (1926) condensed separate genera, *Apelma, Euforcipomyia, Thyridomyia,* and *Ceratopogon,* into a single genus *Forcipomyia* on the basis of the close similarity in the adult structures, especially in the wing, although this genus was subdivided into four groups by the relative lengths of the first hind tarsal segment to the second. According to his system, the present fly, which shows the following proportional lengths in the hind tarsal segments, 16:5:5:4:4 is duly included together with the other known *Apelma* species in the group

[1] Contribution from the entomological laboratory of the Kyoto Imperial University, No. 40.

where the long basitarsal segment is two or more times as long as the second segment.

As stated above, although *Forcipomyia crinume* is distinctly different from the original generic diagnosis of *Apelma* as given by Kieffer in the presence of the empodia in the male fly,[2] this species is thought to belong properly to the *Apelma* group of *Forcipomyia* sensu lato, taken in connection with the presence of the H-shaped chitinization of the male hypopygium and the close similarity of the immature forms, as will be shown in detail below.

The imago of the present species is somewhat similar in coloration to *F. bromelicola* Lutz or *F. edwardsi* Saunders, but it is easily distinguished by the dark brown or dark scutellum, mesopleura, and metapleura. The hypopygium of the male closely resembles that of *F. keilini* Saunders, *F. brevis* Johannsen, and *F. edwardsi* Saunders, but differs in the distinctly setigerous and nonspoonlike styli and less-setigerous ninth sternum.

I am greatly indebted to Prof. Hachiro Yuasa for his kind direction of this work, and I also thank Prof. A. Thienemann for his kind suggestion with regard to the taxonomy of this fly.

## MORPHOLOGY OF THE PUPA

The pupæ are free mummy in type, the larval skin being not retained, depressed dorsoventrally, flattened in general appearance, about 1.7 to 2.5 mm in length in the male and 1.9 to 2.9 mm in the female. The coloration varies from pale yellow to dark brown, according to the stage of development. The pupal exuvia is hyaline and pale yellow, slightly fuscous in the head, thorax, and last abdominal segment.

### HEAD

The head is flattened and somewhat hexagonal in the ventral aspect. The exuvia is slightly brownish on the dorsal side and hyaline on the ventral aspect. The dorsal surface is distinctly sculptured with minute dots or tubercles and provided with the V-shaped epicranial suture which splits open in the process of emergence. On the median triangular area between the arms of the epicranial suture there are two small tubercles each of which bears a small seta. The similar paired tubercles of the median piece are also known in *F. brevis, F. bromelicola,*

[2] In *F.* (*Apelma*) *brevis* Johannsen, according to Johannsen the empodium of the male fly is not completely wanting but vestigial.

and *F. magna,* but the setæ on the tubercles are not mentioned. In the present pupa the lateral pieces are provided with small setæ and sensory pits where the tubercles would be expected in the other species, such as *F. keilini* and *F. palustris.* The ventral surface is almost smooth, slightly rugulose on the shallow median furrow, and distinctly sculptured with minute dots on the areas of the compound eyes. The region of the frontoclypeus is large, and provided with a pair of minute setæ on its marginal region near the base of the labral sheath. The region of the gena forms a distinct flattened ridgelike projection along the caudal margin.

The labral sheath is a small projection. The sheath of the maxillary palpus is comparatively large, arises from the caudal margin between the labral and the genal projections, and protrudes caudad forming a distinct lobe. The labial sheath is very small, externally visible, located along the concave mesal margin of the sheath of the maxillary palpus, and the paired labial sheaths are distinctly separated from each other at the apex of the labral sheath.

The sheaths of the antennæ are very large, pale brown, arise from the laterocephalic corners of the head, extend caudad around the lateral margins of the head, and end between the bases of the wing sheaths and the middle leg sheaths as in *Forcipomyia* (sensu lato) in general. The surface of the antennal sheath is sculptured with minute brown tubercules and obscurely constricted by shallow hyaline furrows corresponding to the segmentation of the imaginal antennæ.

It may be noteworthy that in the present pupa there are a few small setæ on the dorsal region of the head, and a pair of minute simple setæ on the frontoclypeus, while on the pupal head of the *Apelma* group Saunders states that two or three papillæ, but never setæ, occur on the head.

## THORAX

The thorax is flattened. The dorsum of the thorax is almost smooth, slightly sculptured with minute dotlike tubercules on the lateral region, and is not provided with distinct cuticular spinelike projections differing from those of the *Forcipomyia* (sensu stricto), *Atrichopogon, Kempia,* and *Gymnohelea* groups. The cephalic margin of the thorax is deeply invaginated along the cervical membrane. The mesothorax and metathorax are distinctly divided by a V-shaped suture. The lateral area of the thorax is irregularly rugous, being bluntly projected along

the longitudinal line forming a low ridge. The distinction of the areas corresponding to the adult thoracic sclerotization is very obscure. The middorsal suture is extended throughout the entire length of the thorax from the caudal angle of the V-shaped epicranial suture to the tip of the posterior median projection of the thorax. There is one pair of minute sensory pits on the cephalic region near the bases of the prothoracic respiratory horns, one pair of small blunt setigerous papillæ on the middle of the dorsum, and one pair of minute sensory pits on the caudal region of the mesothorax near the laterocaudal concavities of the mesonotum. The caudal end of the mesonotum triangularly projects caudad across the metanotum and is extended to the anterior border of the first abdominal segment forming the posterior median point. Both setæ and papillæ are wanting on this region, differing in this from the *Forcipomyia* group. The caudolateral margins of the mesonotum, between the caudal projection and the bases of the wing sheaths, are almost entirely round as in *F. bromelicola* and *F. keilini,* but each margin bears a minute shallow incision which is not so distinct as in *F. edwardsi, F. magna,* and *F. comis.* The metanotum is completely separated into the lateral halves by the caudal projection of the mesonotum and each half is provided with a minute seta and one or two sensory pits.

The prothoracic respiratory horns (Plate 1, figs. 3 and 4) are long, slender, subcylindrical, drumsticklike, resembling those of *F. comis,* greatly differing from those of *Forcipomyia* (sensu stricto), but rather similar to those of certain Culicoidinæ vermiformes; namely, *Bezzia* and *Palpomyia.* The entire surface is finely rugulous and without distinct imbrication. The distal region is distinctly flattened in circle in the lateral aspect and the mesal surface is somewhat concave. Along the margin of this distal circular area respiratory pores are arranged in a horseshoeshape. These respiratory pores are all round, comparatively large, independently opened, being not confluent, subequal in size to each other, and about eleven in number on each horn. The respiratory horns are movably articulated on special blunt projections. Usually these horns are directed dorsolaterocaudad.

The sheaths of the wings and legs are extended caudad, but not beyond the anterior border of the first abdominal sternum. The sheaths of the wings are comparatively short but broad and sculptured with minute dots on the basal surface. The mesal margins of the paired wing sheaths are parallel in position

and widely separated from each other. The caudal margins of the paired sheaths do not form a straight line, but each is slightly oblique, forming a shallow inverted V in the ventral aspect. On the lateral part of this caudal margin there is a small hump as in the Ceratopogoninæ in general.

The sheaths of the legs are comparatively short but stout and almost smooth. The foreleg sheaths are entirely visible in the ventral aspect. The region corresponding to the femur and tibia is very large, while that of the basitarsus is suddenly narrowed, then the mesal margin of the flattened foreleg sheaths seems to be incised deeply at the joint of the tibia and tarsus. The region corresponding to the tarsus is dilated and flattened distinctly and not provided with distinct constrictions corresponding to the segmentation of the tarsus. The basitarsal region is elongated and somewhat triangular and forms a V-shaped triangular space between the paired basitarsal sheaths. The distal regions of the paired foreleg sheaths which contain the distal four tarsal segments of the adult legs are parallel, extending between the mesal margins of the wing sheaths, closely contiguous to each other on the midventral line and ended far before the distal tip of the wing sheath.

Each middle leg sheath is extended along the lateral side of the forelegs and ended beyond both tips of the forelegs and wing sheaths reaching the same level as the wing humps. The major region of the sheath is hidden under the wing and foreleg sheaths and only the region of the tibia and the distal tip are externally visible. The femoral region is found under the fore tibial region, the tibial region between the fore tibial region and the wing sheath, and the tarsal region excepting its tip under the wing sheath. The tarsal region is distinctly divided into four parts by three brown constrictions. The distal part is suddenly dilated mesad, being closely contiguous with the opposite part and fill up the space between the wing sheaths. The distal two tarsal segments of the imago are found within this part.

The hind leg sheaths are hidden under the wing sheaths and only the distal tips are externally visible. The region of the tibia and femur is extended along the lateral side of the middle leg sheath but the tarsal region is extended laterad and then caudomesad and ended beyond the tips of the wing sheaths on the same level as the middle leg tips, being closely applied with the middle leg sheaths at a right angle. The tarsal region of the hind leg is flattened and large, shallowly and imperfectly

constricted into four parts. The proximal part is large, extended caudolaterad and contains the adult basitarsus. The remaining part is extended caudomesad and dilated distad. The dilated distal part contains the distal two segments of the adult hind leg. The exposed tip of the hind leg sheath is tinged brown and sculptured with minute dots.

The halteres seem to be not provided with their special sheaths, formed within the common space of the metathorax and externally visible through the pupal skin in the dorsal aspect along the anal margins of the wing sheaths.

These principal arrangements of the thoracic appendages seem to be prevalent among the related groups of *Forcipomyia*, judging from the figures given by various writers (Johannsen, Mayer, Saunders, and others).

## ABDOMEN

The larval exuvia is not retained by the pupa, and the pupal abdomen bears distinct setigerous tubercles or papillæ on all sides of each segment and its general appearance somewhat resembles that of *F. comis* and *F. keilini*. On the cephalic two and the penultimate eighth abdominal segments the cuticular projections are somewhat reduced and modified. The surface of each segment is sculptured with minute dotlike brown tubercules and more or less rugulous with longitudinal waved lines on the dorsomesal and ventromesal areas. The sternal side of the first and second segments is covered by the wing and leg sheaths and is quite smooth, without tubercles and papillæ.

Typically six pairs of setigerous tubercles are transversally arranged on each segment as shown in Plate 1, fig. 5. These tubercles are more or less imbricated, at least on the basal region. Of these tubercles the lateral two, *c* and *d*, are provided with a simple seta on each tip; the seta of *c* is very long while that of *d* is minute. The tubercles *b* and *f* are provided with two or more simple setæ on each base. The remaining two, *a* and *e*, are devoid of setæ. Besides these tubercles there are two pairs of sensory pits: one pair on the caudal region of the dorsomeson and the other on the dorsolateris near the tubercles *b*. On the lateral side between the tubercles *b* and *c* the rudiments of the abdominal spiracles are found, being tinged pale brown in the exuvia.

On the first abdominal segment a vestigial setigerous papilla, which takes the place of the tubercle *c*, is found on the dorso-

latus; the tubercle *a* is replaced by a single seta found on the cephalic margin and other tubercles are all completely atrophied. On the second abdominal segment the tubercle *a* is also replaced by a single seta and *c, d, e,* and *f* are all greatly reduced, being represented only by minute papillæ, each of which is crowned with a minute seta. The dorsomedian sensory pits are distinctly present on both the first and second segments. On the eighth abdominal segment the tubercles *d* and *b* are reduced, being replaced by simple setæ. Other tubercles are as well developed as in the other segments. These well-developed tubercles on the caudal abdominal segments are not found in the *Forcipomyia* group, which retains the last larval skin on the caudal four or five pupal segments.

The genital sheaths of both sexes are situated on the ventral side of the ultimate segment. This ventral position of the genital sheaths, according to Saunders, is the most important character that separates the *Apelma* group from the other groups of *Forcipomyia* sensu lato. The ultimate segment is distinctly sculptured with minute brown tubercules but without setigerous tubercles or papillæ. The paired caudal processes (Plate 1, figs. 1 and 2) are subequal in structure in each sex, comparatively slender but not so slender as in *F. comis*, extended caudad almost parallel, distinctly imbricated on the entire length and curved slightly dorsolaterad on the distal half. The genital sheaths are hyaline, without minute tubercles but rugulous with transversal waved lines and partially bilobated by the ventromedian constriction. In the male the genital sheaths are larger than in the female. The *Apelma* group as a whole is provided with a pair of lateral setæ on the bases of the caudal processes, while in the present species the setæ were not observed even in the pupæ just after pupation. Instead of the setæ two pairs of minute pitlike structures are definitely found both in the pupæ (31) and exuviæ (17) of both sexes. Of these pairs one pair is found on the lateral sides near the bases of the genital sheaths and the other on the ventral side of the bases of the caudal processes. Whether these pits are due to the falling out of setæ or not remains unknown.

## MORPHOLOGY OF THE LARVA

The larva is slender, yellowish semihyaline in life, and white in alcoholic specimens, measuring about 5 millimeters in length in the full-grown stage. The setæ are all slender, inconspicuous,

and there are no modified hairs such as the "finned" and blade-like hairs found in *F. edwardsi*, *F. comis*, and *F. magna*.

The larva of the present species is somewhat different from that of the *Apelma* group mentioned by Saunders in the structure of the median posterior prolongation of the body (cauda) and in the chætotaxy of the body. However, judging from the structures of the head, mouth parts, antennæ, prothoracic pseudopod, etc., the present larva possesses many important characters of the *Apelma* group.

## HEAD

The head is pale yellow and heavily thickened and deeply pigmented only on its cephalic and caudal margins, distinctly depressed dorsoventrad, somewhat elongated and oval in shape, the width and the length of the head showing the proportion, 12: 19 (Plate 2, fig. 9). The head is extended in the same axis as the body as in the *Apelma* group, and never directed downwards as in the other groups of *Forcipomyia* (sensu lato); namely, *Thyridomyia*, *Forcipomyia*, *Atrichopogon*, *Kempia*, and *Gymnohelea*.

On the dorsocaudal area of the head there is a delicate epicranial suture. This suture is somewhat U-shaped, distinctly angulated and not extended beyond the eyes, differing from the other known larvæ of the *Apelma* group.

The eyes are found on the laterodorsum on the middle of the head capsule at the ends of the epicranial arms. The mass of the black pigment is comparatively small but distinct, oval in shape in the laterodorsal aspect, and not distinctly bilobated. Upon this pigmental mass a clear small round spot is found.

The antennæ of the present larva (Plate 2, figs. 9 and 11) show a characteristic structure for the *Apelma* group radically differing from the other groups of *Forcipomyia*. They are located on the laterocephalic angles near the base of the labrum, somewhat pyriform, being slightly constricted only on the mesal margins, hyaline, delicately membranous in structure, and set in openings in the chitin of the head. This membranous disk of the antenna consists of two regions. The small cephalic region is the antenna proper, slightly raised and provided with a lunate thickening which suggests the basal portion of the normal larval antenna, and on the central round membrane there are five minute sensillæ. The large posterior region is very slightly tinged yellow contrasting with the peripheral hyaline membrane, on the center there is a deep pore from which many

very minute papillæ are radially arranged in twelve lines. On the constricted mesal margin there is an isolated sensory papilla on the basal brown ring.

The raised feature and annular structure of the present antenna somewhat resemble those of *F.* (*Thyridomyia*) species, although not so conspicuous as in the *Thyridomyia* larvæ. The posterior region of the antenna seems to be more or less developed in the *Apelma* group as a whole, judging from the figures given by Saunders and Mayer, but in the other species this region is far more inconspicuous than in the present larva. This caudal organ appears to resemble somewhat the postantennal organs of the Collembola, but their exact relation is doubtful.

The chætotaxy of the head closely corresponds to that shown by Saunders. The setæ are all simple, slender, dark brown, and grow on the minute membranous tubercles, as shown in Plate 3, fig. 19. There are ten pairs of setæ, four pairs of minute sensory setæ, and three pairs of sensory pits on the surface of the head capsule. Three pairs of long setæ, *a*, *b*, and *f*, are on the dorsum; one pair of small setæ, *c*, near *b*; one pair of closely associated long and short setæ, *j*, at the base of the labrum; three pairs, *d*, *e*, and *h*, on the lateral side; one pair of long setæ, *g*, on the ventromeson and the closely situated long and short setæ *i* at the base of the maxillæ. The arrangement of the minute sensory setæ is as follows: Two pairs, *k*, on the dorsocaudal margin, one pair, *l*, just behind the eyes, and one pair, *m*, on the ventrocaudal margin. The position of the three sensory pits is as follows: One dorsal pair, *n*, is found before the setæ *f* or behind the labrum; one laterocephalic pair, *p*, near the setæ *e*, and one laterocaudal pair, *o*, just behind the setæ *d*. In the present case the ventral pair of setæ, *g*, is found far more caudad than in the other *Apelma* larvæ in which this pair (designated as *y* in the figure of Saunders) is found on the transverse line passing through the setæ *b* and *c*.

## MOUTH PARTS

The mouth opening is entirely on the ventral side, somewhat elliptical in shape and strongly reënforced with chitin on its margin. The various appendages are highly modified and reduced from those of the typical nematocerous larvæ.

The clypeolabrum (Plate 2, fig. 9) is the median cephalic prolongation of the head and there is no distinction of the clypeus and the labrum as they are uniformly thickened on the dorsal aspect. The distal margin of the labrum is membranous

and somewhat extended ventrad and then backwards forming a membranous ridge. The lateral side of the labrum (Plate 3, fig. 16) is provided with a secondary thickened sclerite which is formed by the fusion of the clypealiæ and labraliæ (*ll*). The ectal part of this thickening is mainly represented by the labraliæ which are very thick on the proximal part and become thin on the distal part. The clypeolabrum is quite smooth and provided with only the closely associated short anterior and long posterior setæ (fig. 9, *j*) on its proximolateral margin of the thickened base of each labralia.

On the distoventral membranous area (Plate 3, fig. 16, *lr*) of the labrum, distad of the labralia, there is a pair of sensory organs each of which consists of three minute fleshy papillæ and a brown setigerous tubercule. On the ventromeson of the labral projection there are two similar sensory organs which are closely situated on the thin distal area of the labraliæ. This organ is composed of three trichoid sensillæ, two fleshy papillæ, and one setigerous papilla.

The ental thickening of the labralia forms a projection, which is known as "pieces triangulaires" (Goetghebeur), for the articulation of the premandible, and closely associated with the ental thickening of the clypealia, forming a large rhombic skeleton at the base of the labrum or dorsad of the mandibular chamber.

The ventral surface of the clypeolabrum (Plate 3, fig. 16), caudad of the labralia, is thinly membranous and extends caudad, eventually forming the roof of the mouth cavity. This membranous area consists of the fusion of the epipharynx and epigusta, losing the external marks of the tormæ which divide these two regions and clothed with fine hairs and spines on the median ridge. The cephalic group of the hairs is composed of many minute spines, one pair of short setæ, three hyaline spines, and one pair of long strong setæ. The caudal group is composed of the uniform minute pubescence.

On the ventral membrane of the labrum there is a pair of small solid thickenings, which are known as the premandibles. The term "premandibles" applied to the nematocerous larvæ was proposed by Goetghebeur (1912) for chironomids, but is not homologous with the premandibles of Campodiidæ (Apterygota), and according to Saunders (1924) and Puri (1925) in the Chironomidæ the premandibles are derived from the local secondary thickenings of the labrum.

In the present larvæ the premandibles (Plate 3, fig. 16, *pm*) are innervated from the frontal ganglion, similarly as in the

sensory organs of the labrum, and provided with the large and small paired muscles on each side. The larger of these two muscles extends caudad and ends on the dorsal wall of the head, while the small one ends on the lateral endoskeleton of the labrum. The premandibles of the present larva are moved in the longitudinal plane, as observed by Saunders in the *Forcipomyia* group, differing from the *Chironomus* larvæ in which they are so moved as to hold food between them. In the lateral aspect the premandible is somewhat L-shaped and supported by the ental thickening of the labralia at the angulated part of the former. The cephalic half of the L-shaped premandible is sunk under the epipharyngeal membrane forming the ental part of the premandible. The other half, the ectal part, is smaller than the former part and its apex is bilobated into blunt teeth. In the *Apelma* group Saunders stated that the premandible is divided into two separated pieces, as in *Dasyhelea,* but such a peculiar structure was not observed in this case.

The mandibles (Plate 3, fig. 16, *md*) are accommodated in a special mandibular chamber between the labrum and the maxillæ, very characteristic in form, consisting of a large hollowed proximal portion and a long slender distal portion and abruptly bent near the middle to an angle of nearly 90°, as stated by Saunders in the *Apelma* group. The mandibular chamber is large; its thin dorsal wall is directly continuous with the epipharynx; its ventral wall is the dorsal wall of the maxilla itself and into this chamber the basal portion of the mandible is received. The mandibles are moved in the horizontal plane, but at the same time each mandible is rotated about 90° by the large retractor and extensor tendons so as to have the curved end directed ventrad. Therefore, in this motion the slender distal portion is moved in the vertical plane along the margin of the maxilla. For the articulation of the mandible large strong endoskeletons (pièces triangulaires) arise from the cephalolateral corners of the mandibular chamber.

The tapering distal portion is provided with two spatulate distadentes on its tip. The proxadentes are completely wanting. A strong hyaline isolated spinelike projection is located on the dorsodistal part as in the other chironomid larvæ. The brustia consists of a single row of minute hairs on the mesal side of the slender distal portion. Other hairs are completely obsolete.

The maxillæ (Plate 3, fig. 16, *mx*) are large membranous lobes, occupying the major part of the ventral side of the mouth cavity, arising from the chitin surrounding the mouth

aperture and supported by irregularly-shaped endoskeletons on the dorsal side which arise from the anterior converging wall of the head and by slightly thickened slender stripes (cardo?) found on the dorsal wall of the maxillæ. Posteriorly the paired maxillæ meet above the mentum (known as the labial plate) and form a V-shaped mouth space between them. Near the mesal margin the ventral surface is provided with a single row of very short delicate hairs, on the cephalic corner with a vestigial maxillary palpus and a group of minute sensory papillæ. The maxillary palpus is membranous, sunk within a membranous socket, and crowned with three very minute fleshy papillæ. Near the conjunction of the paired maxillæ there is a chitinized and fleshy sensory papilla on the dorsal surface of each maxilla.

The labium is represented by the mentum (Plate 2, fig. 10, *mt*) only, the other structures being completely atrophied. The mentum consists of hyaline chitin and is connected by a membrane with the posterior thickened margin of the mouth aperture. Although this structure is well developed in the other chironomid larvæ, in this species as well as in the other members of the *Apelma* group it is very small, somewhat trapezoid, bilobate, provided with two teeth on each lobe, and different from the strong, nonserrated, fanlike projection of the *Forcipomyia* sensu stricto group.

The hypopharyngeal region is highly modified and complex in structure, accompanying various modified adjacent sclerites. The essential structure is similar to that in other Ceratopogoninæ shown by Saunders. The hypopharyngeal structures of the present larva does not form a tonguelike projection differing from the chironomid insects and these structures are displaced deeply caudad becoming located on the entrance of the œsophageal canal, as shown in Plate 2, fig. 9. This organ is not a single mass of sclerotization but composed of two main skeletons at least—namely, the dorsal (Plate 2, figs. 12 and 13) and the ventral (fig. 10) parts, and food is passed caudad between these two parts. Thus the ventral part may be homologous with the hypopharynx proper, but there is nothing to correspond to the dorsal part among the other nematocerous larvæ.

The dorsal part consists of a pair of large, strongly chitinized, lateral arms (Plate 2, fig. 12, *la*) and a cordiform central plate (fig. 13). The lateral arms are extended dorsad, and each is provided on its extremity with a group of strong muscles which ends on the dorsal wall of the head, differing from that of *Forcipomyia,* sensu stricto in which the muscles end on the lateral

wall of the head. The ventral end of this arm is firmly and directly connected with the dorsolateral margin of the central plate. These paired endoskeletons are named by Saunders "the winglike sclerites" in the case of *Forcipomyia,* but in the present larva they are merely rod-shaped and not expanded winglike. Although the homology of these conspicuous skeletons has not been discussed by any of the previous investigators, they are probably related to the pharyngea-lingulæ which are laterally extended from the hypopharyngeal center in the Chironominæ in general.

The central plate is distinctly convex ventrad, forming a large cavity on the dorscal side, and shows a somewhat V-shaped cross section. The margin of this plate is thickened, especially on the cephalic half, where it is rounded, and directly connected with membrane of the epigusta. On the ventral surface of this plate there is a distinct V-shaped transverse ridge, in addition to three pairs of small lateral ridges for the grinding of food and a distinct conical tubercle on the cephalic triangular thickened area. The entire ventral surface is sculptured with minute brown dotlike tubercles. On the dorsal or ental surface there is a V-shaped rig for the reënforcement of this plate, and this ental rib is shown as a dark shadow in the ventral aspect. From the caudal margin of this plate a thin narrow plate of chitin extends caudad along its margin; on the dorsal side of this delicate hyaline plate the first row of fine striation is found, and from the caudal margin of this hyaline plate the second row of striation extends onto the delicate œsophageal membrane. These structures have been regarded as the fringe of hairs before the studies of *Forcipomyia* by Saunders. Along the cephalic margin of this cordiform plate Saunders stated that there is a delicate transverse thickened bridge in *Forcipomyia* and *Apelma,* but such a bridge was not observed in the present case.

The ventral plate (Plate 2, fig. 10) mainly consists of a large median plate and accessory paired rods. The median plate is concave on the dorsal surface corresponding to the convex dorsal plate and semicircular in shape in the dorsal aspect. The dorsal concave grinding surface is studded with numerous minute tubercules but without distinct ridges or teeth, and the lateral and cephalic margins are very strongly thickened. The caudal region is comparatively thin and on the ventral ental surface there is a transverse row of thickened tubercles, and between this row of tubercles and the wall of the œsophagus there is a

thin hyaline transverse plate of chitin from which a row of delicate striæ extends caudad onto the œsophageal membrane as in the caudal margin of the dorsomedian plate. The median plate of the ventral part is reënforced by a strong rib which is across its convex ventral surface. On the laterocaudal corners of the median plate a pair of strong tendons is found from which paired muscles extend to the lateral side of the lateral arms of the dorsal part. From the lateral margin of the median plate a pair of strong rodlike endoskeletons (*vr*) extends cephaloventrad and on each end a strong muscle which ends on the ventral wall of the head is attached. In front of the thickened cephalic margin of the ventromedian plate there is a thin cuticular sclerite (*sl*), which is supported by a pair of rods extending from the laterocephalic margin of the median plate. This thin sclerite is continuous with the membrane that connects the dorsal base of the labial plate and maxillæ and may have originated from the salivia. The long common salivary duct (*sd*) extends beneath the ventromedian plate, is distinctly swollen before the aperture on the dorsal side of the thickened ventral rods (*vr*), and opens into the oval salivos between the dorsal margin of the median plate and the thin salivary sclerite (*sl*).

In addition to these structures of the hypopharyngeal sclerites there is an accessory sclerotization (Plate 2, fig. 10, *a–c*) which is named "the lateral rod-system" by Saunders. This internal sclerotization is developed between the ventromedian plate of the hypopharynx and the marginal chitinization of the mouth aperture and consists of three skeletons, the cephalic pair (*a*) of which is strongest but shortest and arises from the highly chitinized marginal portions of the mouth aperture found caudad of the mentum and extended caudad. From the end of this pair two pairs of long (*b*) and short (*c*) slender rods extend caudad and connect with the lateral margins of the median plate. Of these two rods the long dorsal one (*b*) ends on the caudal corners of the median plate, while the short ventral one (*c*) extends obliquely and ends at the base of the ventral rod (*vr*) of the median plate.

### THORAX AND ABDOMEN

The body is slender, composed of the usual three thoracic and nine abdominal segments, and all are slightly depressed dorsoventrally but in alcoholic specimens become swollen cylindrically. The setæ are all slender, small, simple, ordinary in structure and specially finned; bladelike hairs and setiger-

ous tubercles are wanting. Very rarely an aberrant seta (Plate 1, fig. *a*) is found on the dorsum of the first abdominal segment.

The chætotaxy of this larva is distinctly different from that of the *Apelma* group stated by Saunders in reference to that of *F. bromelicola* in the absence of the lateral large setæ and rather similar to that of *F. comis* studied by Mayer excepting the finned hairs.

On each thoracic segment (Plate 1, fig. 6) seven pairs of setæ are shown of which the setæ *a, d,* and *g* are long and simple, while the remaining, *b, e,* and *i,* are small and grow on their independent fleshy minute papillæ. Besides these setæ the thoracic segment is provided with characteristic paired setigerous papillæ (Plate 1, fig. 6, *l,* and fig. *l*) on the venter at the invagination of the leg rudiments. On the prothoracic segment the setæ *d* and *g* are rather shorter and the setigerous papillæ *l* are far better developed than in the other thoracic segments. The seta *i* is often greatly reduced and sometimes wanting.

On the abdominal segments from the first to seventh (Plate 1, fig. 7) typically three pairs of setæ are found on the dorsum, two on the latus, and five pairs on the venter. Of these setæ, *a* and *j* are large and normal, while the others are all tuberculated at the base. On each dorsum of the first, second, seventh, and eighth abdominal segments *a* is very large and *b* is very small, while on the other segments, the third, fourth, fifth, and sixth, *a* becomes small and *b* larger than *a*. On the eighth abdominal segment (fig. 8) the setæ are greatly reduced, being represented only by one pair (*a*) on the dorsum, a tuberculated small seta *f* on the latus, and two tuberculated pairs, *g* and *i,* and one long ordinary pair, *j,* on the venter. On the ultimate ninth segment the arrangement of setæ is somewhat different from that of the preceding segments. The two pairs found on the dorsum are subequal to those of the other segments in their arrangement but the setæ in the position *a* are distinctly smaller than in the other segments. On the latus four setæ are present in the positions *d, e, f,* and near *f,* of which a seta found in the position *e* is tuberculated at the base. On the venter two pairs of setæ are present, of which the two setæ in position *h* are normal in structure, while the two in position *j* are tuberculated at the base.

On the caudal margin of the eighth abdominal dorsum there are two strong simple setæ (Plate 3, fig. 18). These setæ are

not so long as in *F. edwardsi* and *F. bromelicola*, but subequal in proportional length to the setæ in *F. comis*, being slightly shorter than the ultimate segment itself. These two setæ extend parallel and caudad in life, but dorsad in alcoholic specimens; they are very closely situated on a common tubercle, thus differing from the condition in *F. comis*. The basal tubercle is composed of a caudal oval chitinized plate and membranous cephalic sides.

The prothoracic pseudopod exhibits characteristic structures for the *Apelma* group, differing from that of any other related group of *Forcipomyia*. This pseudopod is not divided, forms a conical fleshy protrusion directed ventrocephalad, and is crowned with many slender, curved, hairlike hooklets (Plate 2, fig. 14). These slender hooklets are separated by a bare longitudinal area into two lateral groups and all the hooklets of each group are directed laterad, as clearly shown in a figure given by Saunders. Just behind these groups of hooklets there are one small mesal and three large lateral thornlike hooks (fig. 15) on each side of the median line. These hooks are yellowish, flattened, serrated on one side, and arranged in an oblique line. In number and arrangement these hooks are somewhat different from those of other, related species. On the ventral surface of the remaining proximal area this pseudopod is marked with many transverse rows of minute spines on ridges.

The caudal extremity of the body (Plate 3, fig. 17) is surrounded by fine rugulous ridges bearing minute spines and provided with thornlike hooks on its periphery, a well-developed cauda (*cd*) on its middorsal margin, two pairs of anal gills (*ag*), and a tuberculated ventral projection (*tb*).

The protrusible posterior pseudopods are completely atrophied, and the thornlike hooks are directly studded on the end of the body on either side of the median line. These hooks are golden brown, somewhat flattened, variously serrated on one side, nine on each side, and arranged in two rows. The hooks are conveniently grouped into five types (*a–e*). The dorsal three (*a*) are serrated into small teeth, not sharply pointed, and sometimes provided with dorsal teeth; the lateral two (*b*) on the inner or caudal row are slender, sharply pointed, and very finely serrated; the lateral two (*c*) on the outer or cephalic row are broad, irregularly serrated, and sometimes proved with dorsal teeth; the ventral two are very slender and not serrated on the side—of these hooks the ventral one (*e*) is slenderer than the other (*d*) and ends in two sharp tips,

while the other (*d*) is provided with three or more teeth on the dorsal side of the tip.

The term "cauda" was introduced by Saunders (1925) for the median prolongation of the body above the anus. Although it is said that the cauda of the *Apelma* group is short and bluntly conical, in the present case it (*cd*) is well developed and provided with many, small, pale brown projections, and especially on the caudal side these projections are large and more closely arranged. Near the base of the cauda the dorsal side is pubescent with minute comblike spines as shown in Plate 3, fig. 17.

The anal gills (fig. 17, *ag*) are protruded from either side of the anus and deeply bilobated into large gills, and each is again bilobated partially into small projections, so that there are in all eight delicate pointed processes, as in the other *Apelma* larvæ.

The ventral tuberculous projection (fig. 17, *tb*, and fig. 20) consists of about thirty-seven minute, thickened, papilliform tubercles which are closely arranged in an oval area on a blunt, ventral, fleshy projection. Along the cephalic margin of the tuberculous area there is a narrow special area composed of minute membranous papillæ. From the caudal margin of the tuberculous area a pair of brown setigerous belts extends towards the anus in the shape of a U. The membranous area between these setigerous belts is somewhat more pubescent, with very fine spines and provided with four strong, short setæ on the meson and six similar setæ on the ventral margin of the anus, as shown in fig. 17. An isolated strong seta is found along the lateral side of each setigerous belt near the bases of the hooks *d* and *e*. In the related species *F. comis* this tuberculous projection consists of paired tuberculous patches bearing minute hooklets.

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# ILLUSTRATIONS

[Drawings by M. Tokunaga.]

## PLATE 1. FORCIPOMYIA CRINUME (TOKUNAGA)

FIG. 1. Genital sheath of male pupa, ventral aspect.
2. Genital sheath of male pupa, lateral aspect.
3. Sinistral prothoracic respiratory horn of female pupa, caudal aspect.
4. Sinistral prothoracic respiratory horn of female pupa, mesal aspect.
5. Sixth abdominal segment of female pupa, sinistral half, caudal aspect; *a–f*, setigerous tubercles; *g*, and *h*, sensory pits; *s*, rudimental spiracle.
6. Larval chætotaxy, thoracic segment. Sinistral square: dorsum; dextral square: venter; median square: lateral fold; *l:* setigerous papilla on the rudiment of leg; *s:* rudimental spiracle; circle by dotted line: prothoracic pseudopod.
7. Larval chætotaxy, typical abdominal segment.
8. Larval chætotaxy, eighth abdominal segment; *a–k*, setæ.
a. Aberrant seta of larva.
l. Setigerous papilla found on rudiment of thoracic leg.

## PLATE 2. FORCIPOMYIA CRINUME (TOKUNAGA)

FIG. 9. Head-capsule of full-grown larva, dorsal aspect; *a–j*, ten pairs of setæ; *k–m*, minute sensory setæ; *n–p*, sensory pits.
10. Ventral part of hypopharyngeal region of larva, with mentum, membranes omitted, ventral aspect; *a–c*, accessory endoskeletons; *mt*, mentum; *sd*, salivary duct; *sl*, salivary sclerite (salivia); *vr*, ventral rod.
11. Right antenna of full-grown larva, laterodorsal aspect.
12. Dorsal part of hypopharyngeal region of larva, dextral half removed, dorsal aspect; *la*, lateral arm.
13. Dorsomedian plate of hypopharyngeal region of larva, ventral aspect.
14. Slender hairlike hooklet of larval prothoracic pseudopod.
15. Thornlike hooks on one side of larval prothoracic pseudopod.

## PLATE 3. FORCIPOMYIA CRINUME (TOKUNAGA)

FIG. 16. Larval mouth parts, dextral maxilla removed, ventral aspect; *ll*, labralia; *lr*, labrum; *md*, mandible; *mx*, maxilla; *pm*, premandible.
17. Caudal end of abdomen, dextral half, full-grown larva, caudal aspect; *a–e*, various thornlike hooks; *ag*, anal gill; *cd*, cauda; *tb*, tuberculous projection.
18. Setigerous tubercle of eighth abdominal dorsum, full-grown larva.
19. Tuberculated hair of larval head capsule.
20. Tuberculous projection, ventral aspect.

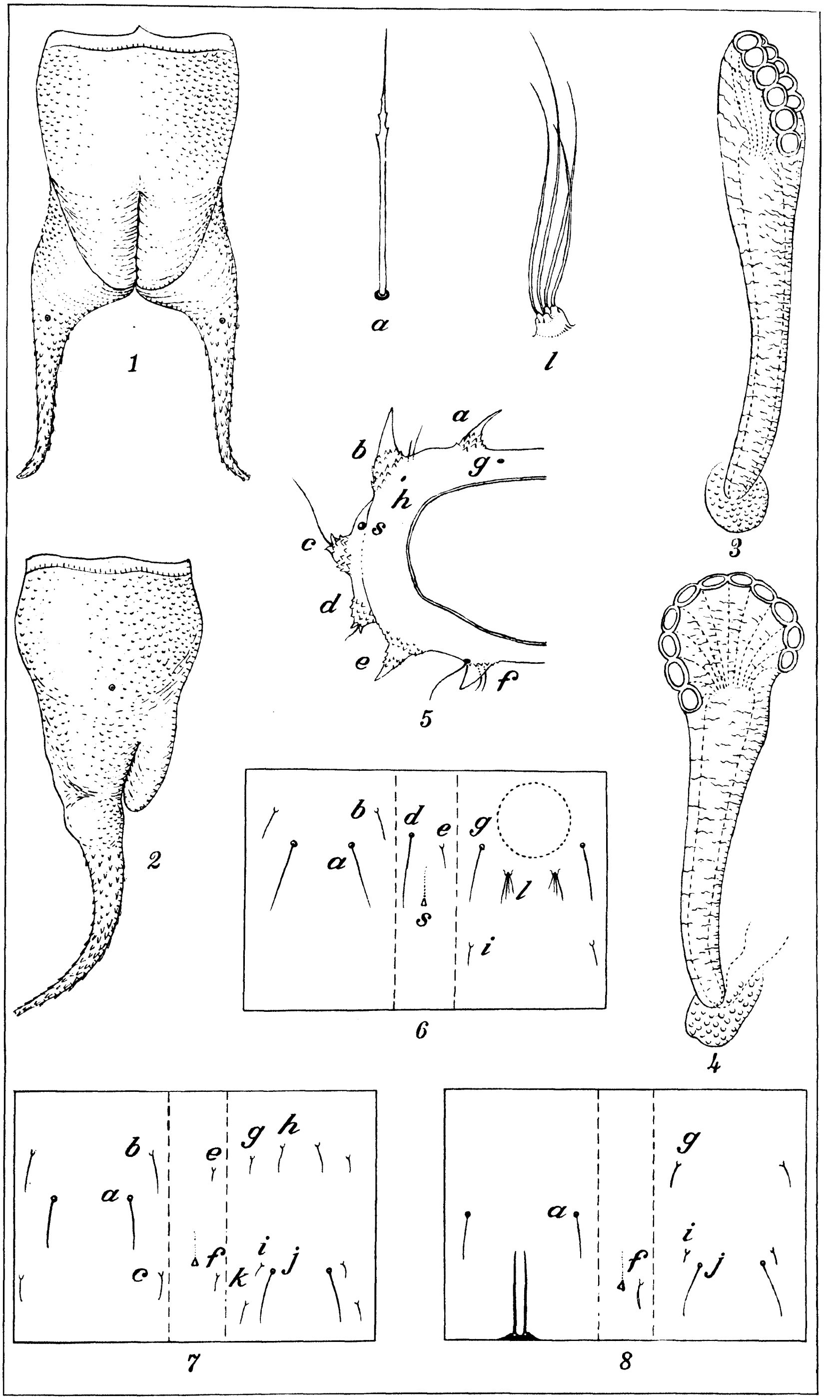


PLATE 1.

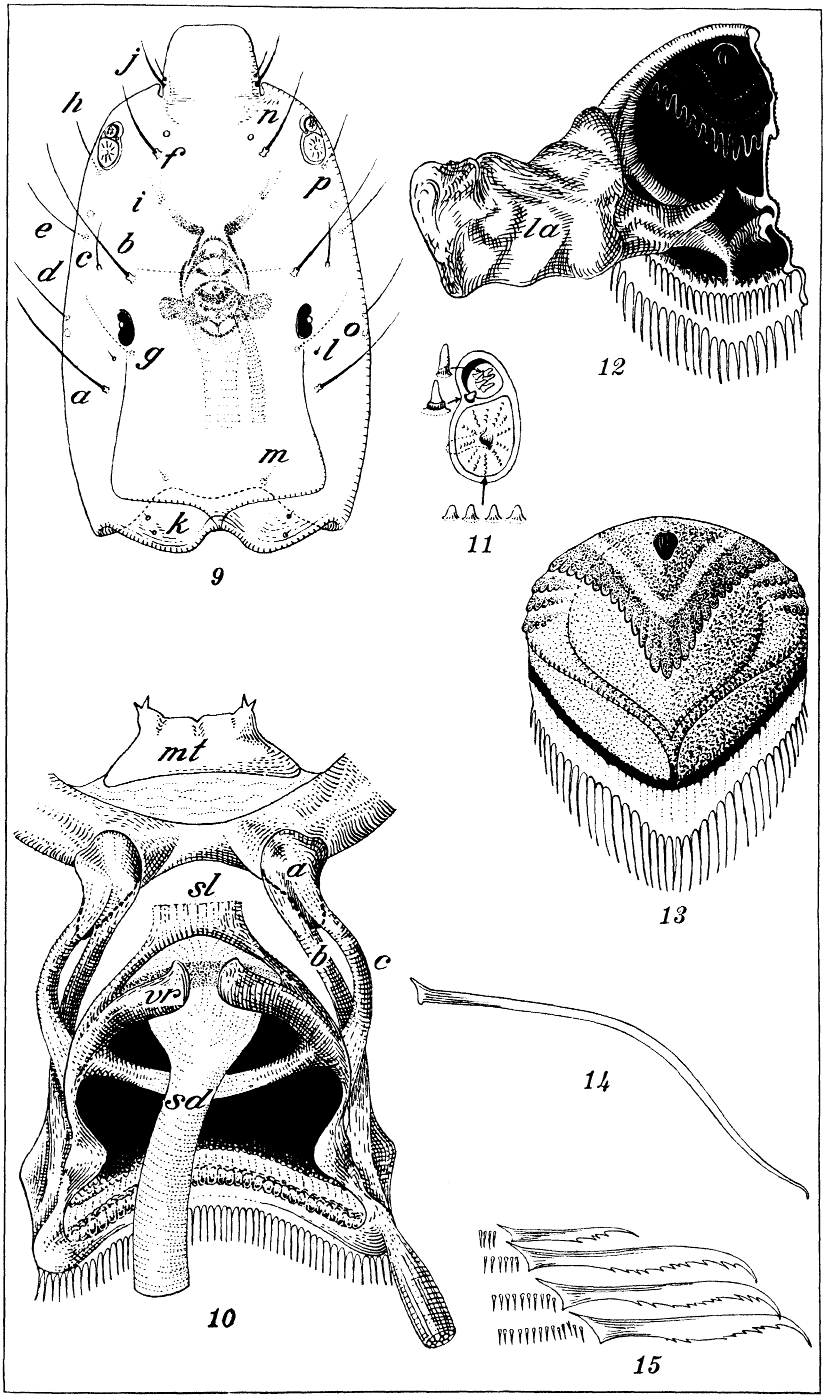


PLATE 2.

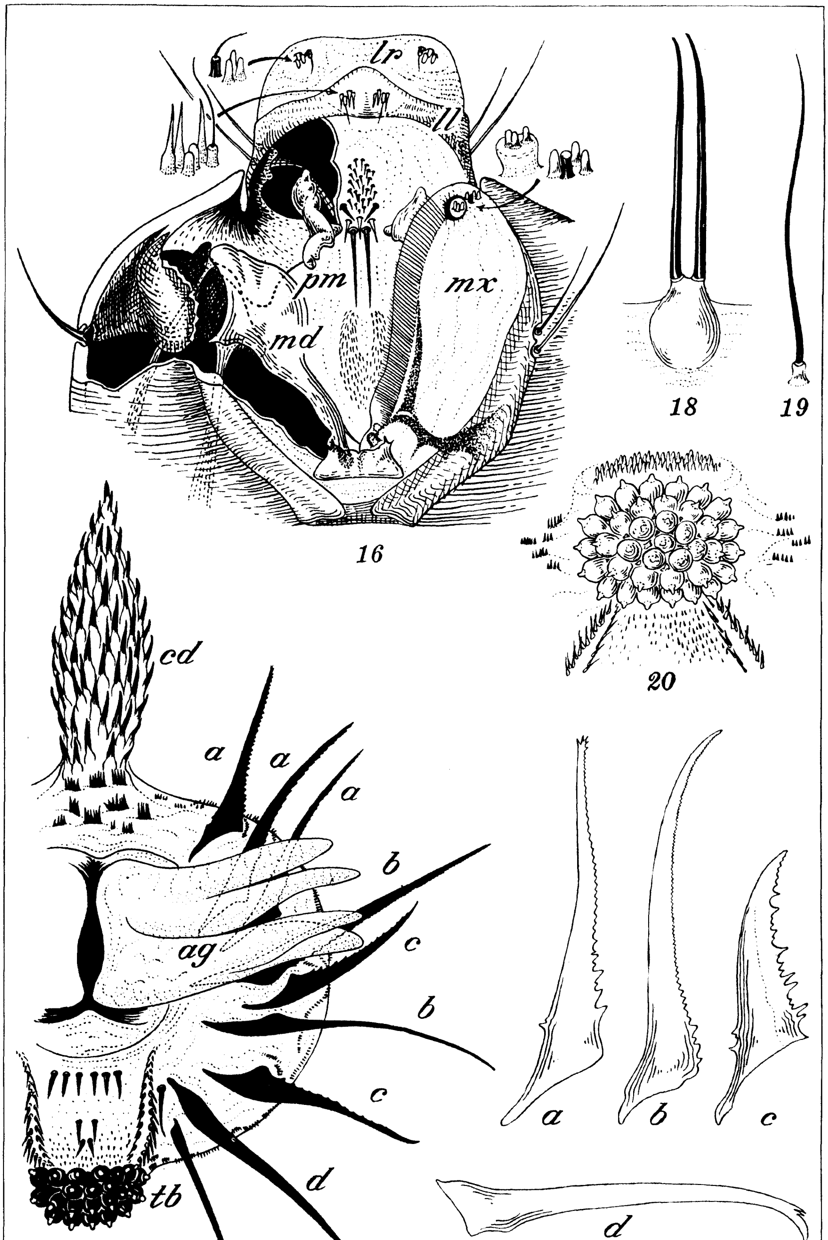


PLATE 3.

# THE COMPOSITION OF PHILIPPINE WOODS, VI [1]

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and

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FOUR PLATES

This paper is a continuation of our work on the composition of Philippine (tropical) woods and makes the sixth report in this series of publications.[2] The composition of woods is a matter of considerable importance for industries that use wood as their basic raw material. An account of the general properties of the woods recorded in this paper is given by Schneider.[3] Brief descriptions are as follows:

Apitong (*Dipterocarpus grandiflorus* Blanco) is one of the important members of its genus. This genus belongs to the dipterocarp, or lauan, family which is by far the most prominent family of trees in the Philippines. The dipterocarp forests cover about 75 per cent of the virgin forest area (30,000 square miles) of the Philippines and contain approximately 95 per cent of the total amount of standing timber in the Islands. They are found on nearly all types of topography.

These woods are everywhere utilized for a wider range of uses than those of any other family. The most characteristic feature of these trees is that they contain resin ducts. When the bark and sapwood are cut the oily resin exudes more or less freely and, on exposure to the air, the resin hardens into a sticky, pasty mass.

Apitong, like most other dipterocarps, is a large tree which reaches a diameter of 100 to 150 centimeters and a height of 40

[1] This work is carried on coöperatively by the division of chemical research, Bureau of Science, and the Bureau of Forestry.

[2] Yenko, F. M., Luz Baens, A. P. West, and H. M. Curran, Philip. Journ. Sci. 47 (1932) 281 and 343; 48 (1932) 299; 49 (1932) 587; 52 (1933) 209.

[3] Bull. P. I. Bur. Forestry 14 (1916).

to 50 meters. It usually has a straight, regular bole. According to Schneider the wood of all species of dipterocarps is practically identical as far as structure goes; in weight, hardness, and color the differences between various species seem to be no greater than those found between individuals of the same species growing in different regions. All are classified as apitong in commerce.

Like other dipterocarps the wood of apitong is moderately hard to hard, stiff and strong, and moderately heavy to heavy. The texture is rather coarse and the wood has a resin odor when fresh. If not seasoned carefully the wood is liable to warp. It has a durability of 3 and it is not commonly attacked by beetles, though occasionally by dry rot. The wood is used for cheap and medium-grade furniture and for general construction work.

Gatasan (*Garcinia venulosa* Choisy) is a tree which reaches a diameter of 40 centimeters. It has hard wood that is heavy to very heavy and generally yellow in color, though some specimens are red. The grain is straight and the texture fine, dense, and glossy. This wood seasons without warping, but is liable to split. Although it does not saw easily it is not otherwise difficult to work. The durability is about 2 and it is not attacked by beetles. It is used for general construction work. The red variety has an excellent reputation for posts.

The particular oak wood analyzed for this report was Bennett's oak, or pangnan (*Quercus bennettii* Miquel). Oak trees generally grow in the mountainous regions of the Philippines. Some are tall trees, reaching diameters of 40 to 100 centimeters. The wood is usually moderately hard to hard and heavy to very heavy. The texture is fine and dense in most specimens, though somewhat porous in others. It has a durability of about 3 and is not attacked by beetles. It seasons well if carefully stacked and may be used for all kinds of construction work.

Camagon (*Diospyros discolor* Willdenow) is the largest and best known tree of its genus. It ordinarily grows to a diameter of 60 centimeters or more. The relative amounts of sapwood and heartwood vary considerably in different specimens, and the color of the sapwood varies from pinkish to pale red. The wood is hard, heavy, and has a high specific gravity. The grain is generally very straight and the texture fine and very dense in the heartwood. It is difficult to season and to work, but takes a beautiful surface under sharp tools. The heartwood has a durability of 1 and the sapwood 2. The wood is used for numerous

purposes and is especially suitable for musical instruments, cabinetwork, and furniture.

Tanglin (*Adenanthera intermedia* Merrill) is a tree that grows to a diameter of 70 centimeters. The wood is hard and heavy. The texture is fairly fine and glossy and resembles that of ipil. The wood seasons well and has a durability of 2. It is used for general construction work.

Tináan-pantai (*Cyclostemon bordenii* Merrill) grows to a diameter of 95 centimeters. The wood is hard and heavy. The grain is very straight and the texture fine and dense. If sawn when fresh and carefully stacked, it seasons with little staining and checking. Although a hard wood, it is not difficult to saw and is easy to shape and surface. The durability is 3, and it is not attacked by beetles. This wood is especially useful for all sorts of interior work.

Amugis (*Koordersiodendron pinnatum* Merrill) is a tall straight tree that may reach a diameter of 100 centimeters. The wood is hard and heavy and the texture fine. The durability is 3, and it is rarely attacked by insects. It may be used for furniture, cabinetwork, and general construction.

Narig (*Vatica mangachapoi* Blanco) is a tall slender tree that may reach a diameter of 70 centimeters. The wood is hard and heavy. The texture is very fine and dense, with a fine, straight grain. It seasons well and is fairly easy to surface. It has a durability of 1 and is used for permanent construction.

Tuai (*Bischofia javanica* Blanco) is a tall straight tree that sometimes grows to a diameter of 150 centimeters. The wood is moderately hard and heavy. The color of the sapwood varies from light cream to reddish brown. The heartwood is dark reddish brown with a purplish tinge. The texture is coarse. This wood checks and warps badly if not seasoned very carefully, but is fairly easy to work. The durability is about 3. It is used for various purposes, such as posts, beams, and foundation piling.

Kalukoi (*Ficus malunuensis* Warburg) is a medium-sized tree. It is found at low to medium altitudes, scattered in the open as well as in the forest, and grows to a diameter of 60 centimeters. The bole is straight and heavily buttressed. The bark is rather white, but when cut, the color varies from yellow to orange and the bark exudes a watery sap.

Kalumpit (*Terminalia edulis* Blanco) grows to a diameter of 60 centimeters or more. It is a tall straight tree. The wood

is moderately hard and heavy. The texture resembles that of talisay but is somewhat finer and glossier. This wood has a durability of 3 and imparts a yellow color to water. It is used for beams, joists, posts, and for furniture and cabinetwork.

Tamayuan (*Strombosia philippinensis* Rolfe) grows to a diameter of 50 centimeters. The wood, though brittle, is hard and heavy. It has a very fine, dense, and smooth texture. It seasons with little warping, is easy to work, and takes a smooth, silky surface under a sharp plane. The durability is 2. It is used for piles, posts, beams, mine timbers, tool handles, furniture, and cabinetwork.

In Table 1 are given the measurements of the trees from which samples were taken for our analyses.

TABLE 1.—*Measurements of Philippine trees used for wood analysis.*

| Name of tree. | Diameter. | Total height. | Clear length of trunk. | Height from which specimen was taken. | Specific gravity of wood. |
|---|---|---|---|---|---|
| | *cm.* | *m.* | *m.* | *m.* | |
| Apitong; [a] *Dipterocarpus grandiflorus* | | | | | |
| Gatasan; *Garcinia venulosa* | 30.0 | 16.0 | 5.7 | 2.00 | 0.886 |
| Oak; *Quercus bennettii* | | 21.8 | 6.0 | | 0.959 |
| Camagon; *Diospyros discolor* | | 22.9 | 6.4 | | 1.218 |
| Tanglin; *Adenanthera intermedia* | 26.0 | 16.0 | 6.0 | | 1.057 |
| Tinaan-pantai; *Cyclostemon bordenii* | 29.0 | 18.6 | 8.0 | | 0.946 |
| Amugis; *Koordersiodendron pinnatum* | 21.0 | 20.0 | 9.0 | 1.68 | 0.800 |
| Narig; [a] *Vatica mangachapoi* | | | | | |
| Tuai; *Bischofia javanica* | 44.0 | | 11.5 | | 0.810 |
| Kalukoi; *Ficus malunuensis* | 21.3 | 14.5 | 5.4 | 0.75 | 0.448 |
| Kalumpit; *Terminalia edulis* | 42.0 | 21.0 | 12.0 | 2.64 | 0.598 |
| Tamayuan; *Strombosia philippinensis* | 26.0 | 16.0 | 6.0 | | 1.09 |

[a] These trees were of average mature size. The measurement records were lost.

In analyzing the wood samples we followed, in general, the methods adopted by the forest-products laboratory at Madison, Wisconsin.[4] We introduced certain details in the analytical procedure[5] because we found by previous experience that this increased the accuracy of the results.

The results of analyzing the woods recorded in this paper are given in Table 2.

[4] Bray, M. W., Paper Trade Journ. 87 No. 25 (1928) 59. Schorger, A. W., Chemistry of Cellulose and Wood (1926) 505.

[5] Yenko, F. M., Luz Baens, A. P. West, and H. M. Curran, Philip. Journ. Sci. 47 (1932) 343.

TABLE 2.—*Analysis of Philippine woods.*

[The percentages were calculated on a moisture-free basis.]

| Constituent. | Apitong; *Dipterocarpus grandiflorus.* | Gatasan; *Garcinia venulosa.* | Oak; *Quercus bennettii.* | Camagon; *Diospyros discolor.* | Tanglin; *Adenanthera intermedia.* | Tinaan-pantai; *Cyclostemon bordenii.* |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Cold-water soluble | 1.61 | 4.57 | 4.32 | 4.56 | 4.82 | 4.51 |
| Hot-water soluble | 5.07 | 8.28 | 6.97 | 8.12 | 7.16 | 5.70 |
| Alkali soluble | 16.12 | 21.60 | 15.86 | 21.12 | 17.44 | 16.05 |
| Ether extract | 1.38 | 4.77 | 0.29 | 1.35 | 1.97 | 0.71 |
| Alcohol extract | 2.61 | 6.76 | 3.96 | 6.35 | 5.76 | 3.29 |
| Ash | 0.99 | 1.45 | 0.33 | 1.33 | 0.82 | 1.66 |
| Nitrogen | 0.53 | 0.32 | 0.36 | 0.29 | 0.19 | 0.37 |
| Lignin | 35.19 | 34.84 | 34.67 | 33.66 | 34.91 | 31.61 |
| Cellulose | 47.60 | 50.97 | 57.32 | 49.12 | 52.43 | 52.77 |
| Ash in cellulose determined. | 0.55 | 0.04 | 1.32 | 0.49 | 0.28 | 0.30 |
| Cellulose ash free | 47.05 | 50.93 | 56.00 | 48.63 | 52.15 | 52.47 |
| Alpha cellulose in total cellulose. | 74.13 | 73.68 | 71.31 | 70.79 | 76.38 | 79.70 |
| Alpha cellulose in the wood. | 35.29 | 37.55 | 40.87 | 34.77 | 40.05 | 42.06 |

| Constituent. | Amugis; *Koordersiodendron pinnatum.* | Narig; *Vatica mangachapoi.* | Tuai; *Bischofia javanica.* | Kalukoi; *Ficus malunuensis.* | Kalumpit; *Terminalia edulis.* | Tamayuan; *Strombosia philippinensis.* |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Cold-water soluble | 0.82 | 4.75 | 1.71 | 3.18 | 4.53 | 1.33 |
| Hot-water soluble | 2.41 | 7.13 | 3.38 | 4.93 | 8.30 | 2.92 |
| Alkali soluble | 18.43 | 23.53 | 28.94 | 13.05 | 19.86 | 11.87 |
| Ether extract | 0.95 | 1.76 | 0.47 | 0.62 | 0.41 | 0.78 |
| Alcohol extract | 1.97 | 6.66 | 0.36 | 2.85 | 5.31 | 1.70 |
| Ash | 1.07 | 0.48 | 1.53 | 3.03 | 0.41 | 0.57 |
| Nitrogen | 0.28 | 0.27 | 0.30 | 0.53 | 0.25 | 0.41 |
| Lignin | 33.76 | 30.40 | 48.00 | 30.00 | 33.51 | 36.56 |
| Cellulose | 51.65 | 53.19 | 41.53 | 56.13 | 51.26 | 50.65 |
| Ash in cellulose determined. | 0.23 | 0.22 | 0.30 | 0.43 | 0.13 | 0.29 |
| Cellulose ash free | 51.42 | 52.97 | 41.23 | 55.70 | 51.13 | 50.36 |
| Alpha cellulose in total cellulose. | 76.75 | 74.12 | 72.92 | 77.19 | 70.75 | 81.69 |
| Alpha cellulose in the wood. | 39.64 | 39.42 | 30.28 | 43.33 | 36.27 | 41.38 |

## SUMMARY

Twelve samples of Philippine woods were analyzed in this investigation. These woods have the common names apitong,

gatasan, oak, camagon, tanglin, tinaan-pantai, amugis, narig, tuai, kalukoi, kalumpit, and tamayuan.

As shown by the data (Table 2) tuai wood had the highest content of lignin (48 per cent). Oak wood had the highest cellulose (57.32 per cent). The wood that contained the highest percentage of alpha cellulose was kalukoi (43.33 per cent). Cellulose obtained from the tamayuan wood had the highest content of alpha cellulose (81.69 per cent).

# ILLUSTRATIONS

PLATE 1

FIG. 1. Apitong; *Dipterocarpus grandiflorus* Blanco.
2. Gatasan; *Garcinia venulosa* Choisy.
3. Oak; *Quercus bennettii* Miquel.

PLATE 2

FIG. 1. Camagon; *Diospyros discolor* Willdenow.
2. Tanglin; *Adenanthera intermedia* Merrill.
3. Tinaan-pantai; *Cyclostemon bordenii* Merrill.

PLATE 3

FIG. 1. Amugis; *Koordersiodendron pinnatum* Merrill.
2. Tuai; *Bischofia javanica* Blanco.
3. Kalukoi; *Ficus malunuensis* Warburg.

PLATE 4

FIG. 1. Kalumpit; *Terminalia edulis* Blanco.
2. Tamayuan; *Strombosia philippinensis* Rolfe.

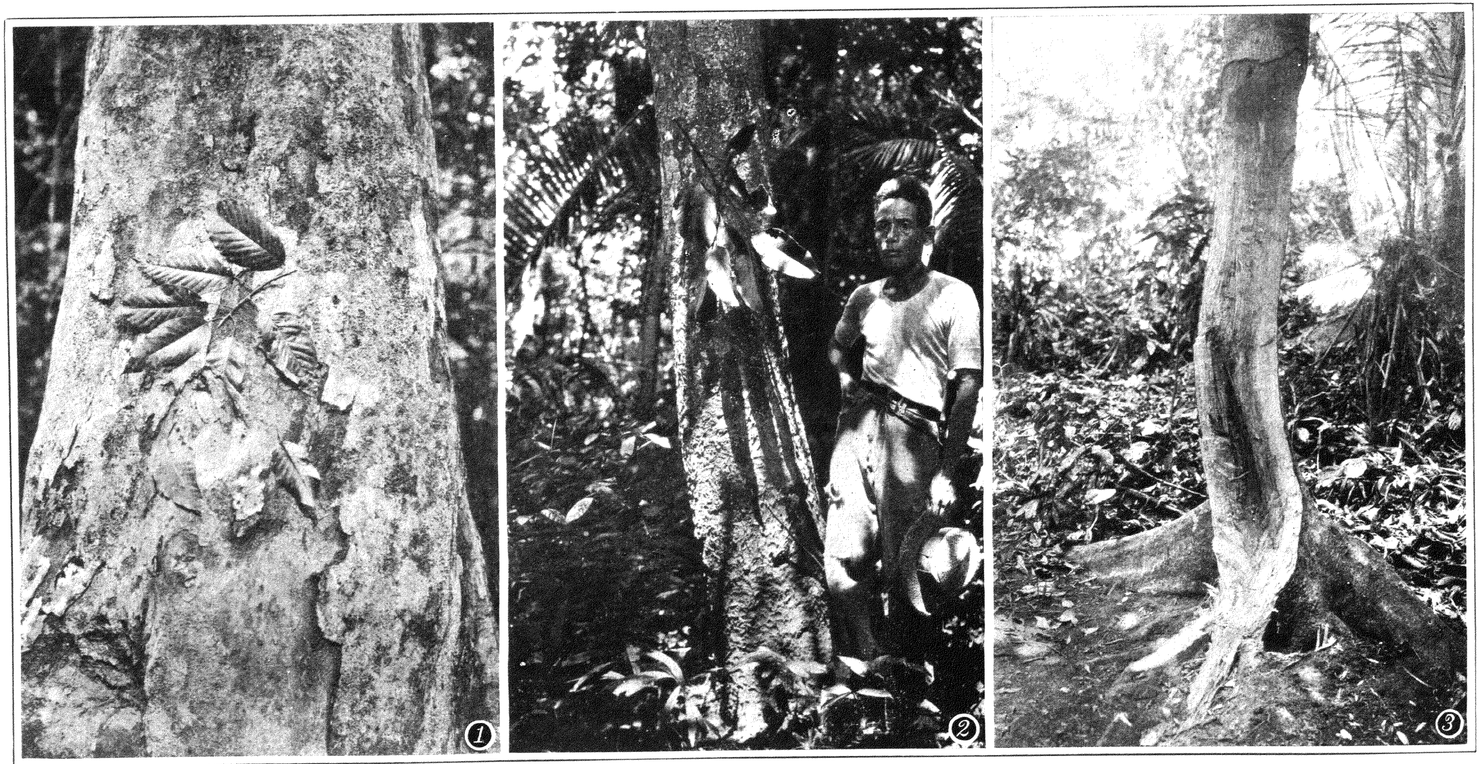
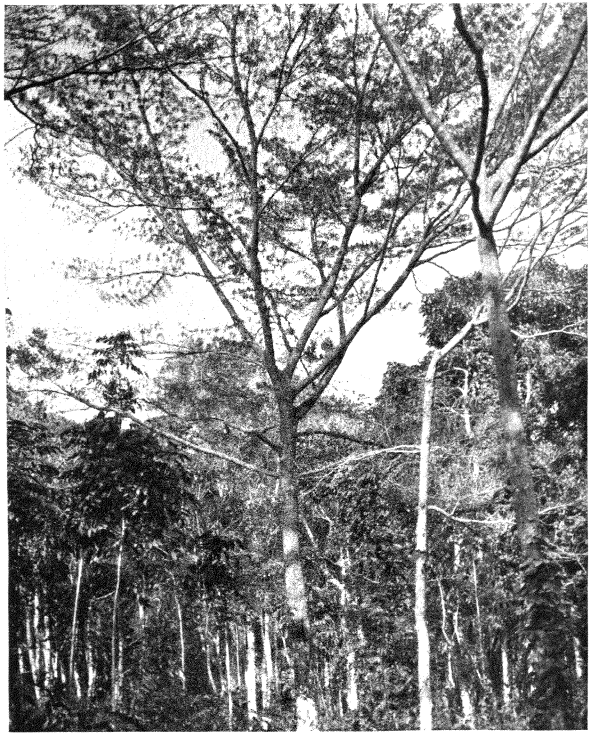


PLATE 1.


PLATE 2.

PLATE 3.



1

2

PLATE 4.

# AN AUTOMATIC DISTRIBUTING MACHINE FOR PARIS GREEN MIXTURES [1]

By PAUL F. RUSSELL

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and

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TWO PLATES AND TWO TEXT FIGURES

Malaria in the Philippines is carried by stream-breeding anophelines and, at present, there are no other known vectors. Swamps, rice fields, ponds, salt-water pools and lagoons, although prolific sources of anophelines of several species, do not appear to menace the health of nearby communities. The problem of malaria prophylaxis, so far as larvicidal measures are concerned, is limited to the control of streams. The classical picture of marsh-fever is not seen. Not the lowlands, but the well-drained foothill areas, are malarious.(1, 2)

Paris green, applied to streams, although not widely used in the Philippines, has successfully controlled malaria in several places throughout the Archipelago. The most notable success has been that at Fort Stotsenburg.(3, 4, 5) There seems to be little doubt that this larvicide can be used effectively here as elsewhere. But, as in all tropical areas, the cost of malaria control in the Philippines is more than most communities can bear. This is true despite the fact that Tiedeman(6) succeeded in controlling malaria at a cost of only 30 cents United States currency per capita per year.

It costs approximately 183 dollars per 10,000 meters of stream bank per year in this country to control anopheline breeding by the use of Paris green. Of this amount, approximately 52

[1] This machine was designed and built at the College of Engineering, University of the Philippines, at the suggestion of Malaria Investigations of the Bureau of Science. Malaria Investigations is jointly supported by the bureau and by the International Health Division of the Rockefeller Foundation. The authors make grateful acknowledgment of the assistance of Dean Hyde, of the College of Engineering.

dollars represents the cost of materials and 131 dollars the cost of labor. Moreover, as elsewhere in the Tropics, the labor is not always satisfactory as regards the intelligent or even faithful application of the larvicidal mixture. Therefore, to the above costs must be added those of supervision. It appears that cost of labor and, above all, the expensiveness of supervision, have been real barriers to practical malaria control in the Philippines, except in a few populous places. In many areas not only in the Philippines but elsewhere in the Far East, a per capita expenditure of more than 5 cents United States currency per annum for malaria prophylaxis is not feasible.

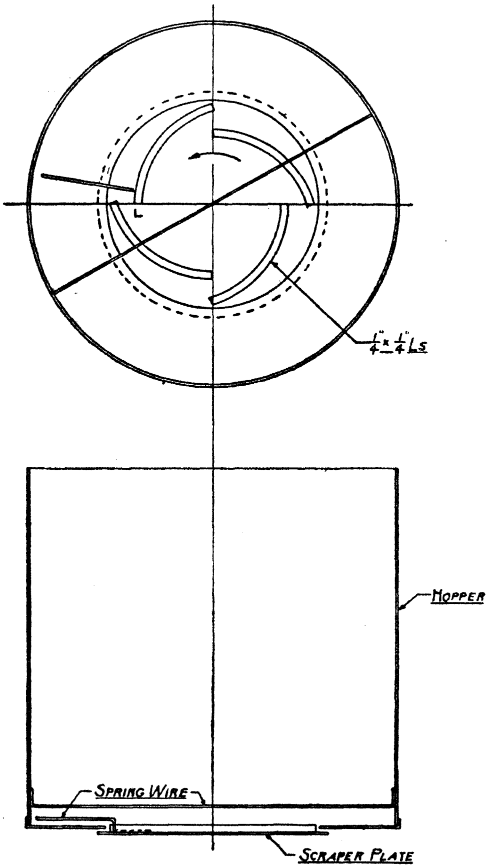


**Fig. 1.** Automatic distributor of Paris-green mixtures. Diagrammatic cross section of hopper. L represents section of angle iron in elevation. Ls, angle irons. Scale, approximately, 1/6 of full size.

Economically malaria prophylaxis is essentially a matter of time and money. If money is available in large amounts malaria prophylaxis can be accomplished in a relatively short time. If, on the other hand, a small annual appropriation is used intelligently and continuously it will in time reduce the malaria rate to a reasonable figure.

For some years we have been experimenting with various devices in an attempt to make possible the automatic distribution of Paris green in streams. Such a machine, if effective, would materially reduce the cost of control and would also make more certain the application of the larvicidal dust. A simple gravity distributor has already been reported by one of us.(7) The present paper gives

details of a machine which is motivated by the stream over which it is placed. It is an improvement over the gravity device because it will distribute the usual finely powdered mixtures, whereas the first machine required a heavier, sand mixture to avoid clogging. This second machine may also be weight-driven, as will be reported later.

DESCRIPTION

This power-driven powder distributor is made of galvanized metal sheeting, iron castings, and a steel rod. The hopper is 1 foot high with a diameter also of 1 foot. The paddle is 1 foot high and 13 inches in diameter. The most important parts are the hopper, the revolving plate, and the paddle wheel. The latter is of the S-rotor type. The capacity of the machine is 20 liters and it empties in twenty-four hours at average speed. The time of emptying will depend, of course, on the speed at which the plate turns and on the size of the opening, which is adjustable.

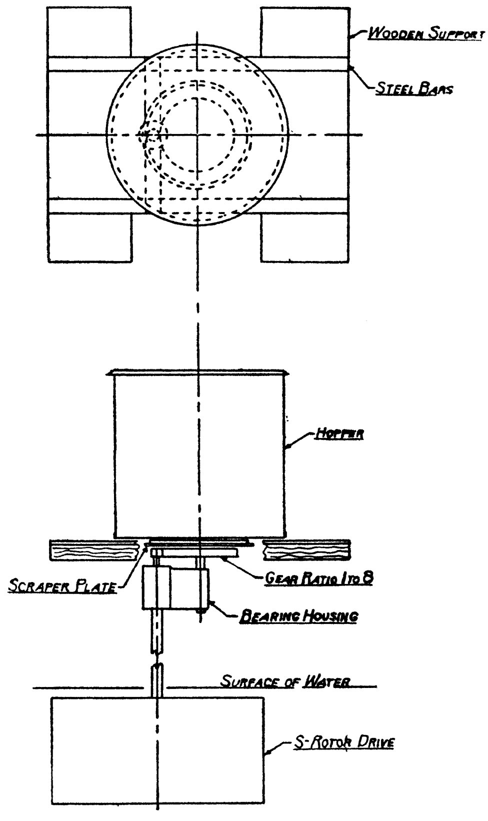


FIG. 2. Automatic water-driven distributor of Paris-green mixtures. Diagrammatic. Scale 1/12 of full size.

The Paris-green mixture falls from the machine to the stream and is distributed by the currents of water. As noted in the first paper(7) the eddies and whirlpools of the stream give a fairly good distribution so that the larvicide is effective for several hundred meters. Naturally, not all streams could be treated in this way and in some cases not all the larvæ will be killed. But it is possible in many streams so to reduce the incidence of larvæ that there will be less than the

critical number of adult mosquitoes necessary to the propagation of malaria. Ross(8) showed that it is not essential to destroy literally every malaria-carrying mosquito to control malaria. Complete eradication, although sometimes feasible, is usually too costly a procedure. It is a week by week, continuous attack on the larvæ that is most important. Where time is abundant and money scarce it is not possible to use the most efficient method. One must choose between no control at all or such modest measures as may in time produce the desired results.

These machines can be built locally for three dollars United States currency each. Therefore, several may be used in the same stream, located at strategic points. Baffle boards may be used in the stream just below the machine to direct the floating larvicide to the edges.

Any of the usual dust mixtures may be used. We prefer powdered charcoal because of its cheapness locally and its floating properties. The outlet of the machine is adjustable so that the volume of flow may be regulated to the needs. In some places it may be necessary to increase the percentage of Paris green from the usual 1 to 99 proportion. Each stream will require special study, but once the machines are erected the labor factor becomes greatly reduced.

Other possibilities suggest themselves. For example, possibly wind-driven distributors could be used in some areas. The type of distributor presented in this paper could be adapted for either a weight or a wind drive at a slightly greater cost.

## SUMMARY

This paper presents an automatic distributing machine for Paris-green mixtures. This powder distributor is motivated by the current of the stream in which the larvicide is to be distributed. It is a low-priced and effective mechanism, which in some places will materially reduce the cost of malaria prophylaxis.

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# ILLUSTRATIONS

PLATE 1

FIG. 1. Automatic distributor of Paris-green mixtures. Paddle wheel.
2. Automatic distributor of Paris-green mixtures. Inside of hopper.
3. Automatic distributor of Paris-green mixtures. Gears and supports.

PLATE 2

FIG. 1. Automatic distributor of Paris-green mixtures. Machine in place over a stream.
2. Automatic distributor of Paris-green mixtures. Machine in place over a stream. Near view.

TEXT FIGURES

FIG. 1. Automatic distributor of Paris-green mixtures. Diagrammatic cross section of hopper. L represents section of angle iron in elevation. *Ls*, angle irons. Scale, approximately, 1/6 of full size.
2. Automatic water-driven distributor of Paris-green mixtures. Diagrammatic. Scale 1/12 of full size.

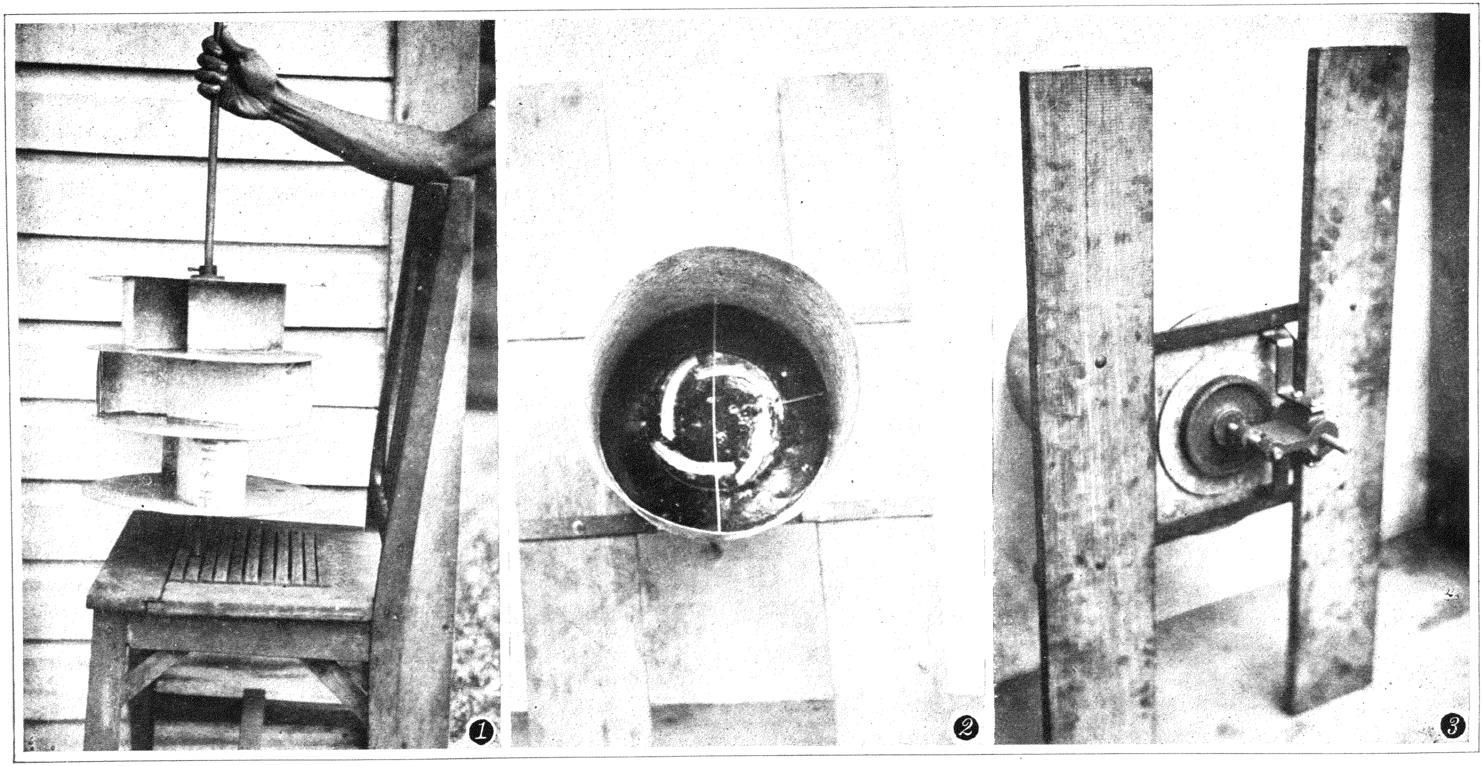
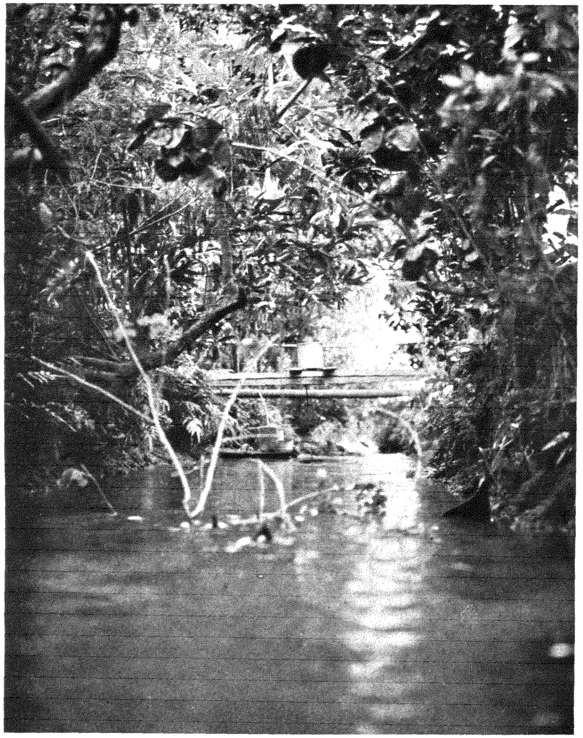


PLATE 1.



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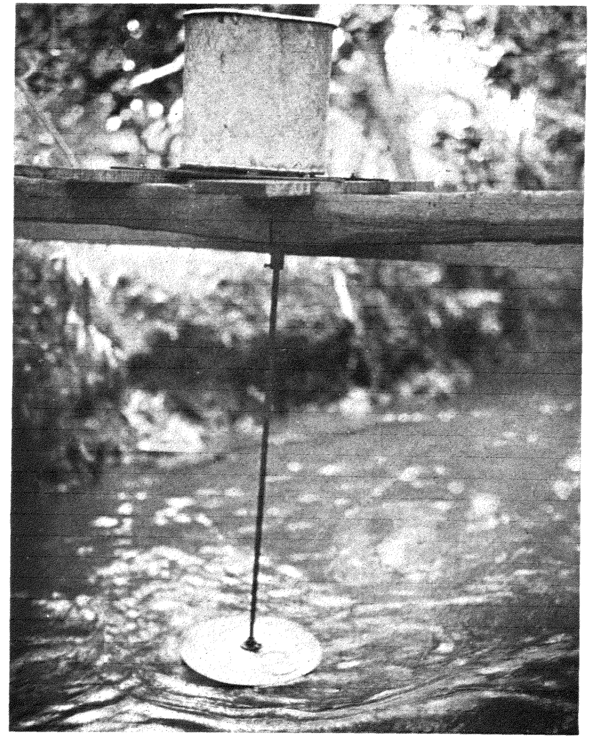

2

PLATE 2.

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[New names and new combinations are printed in **boldface**.]


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